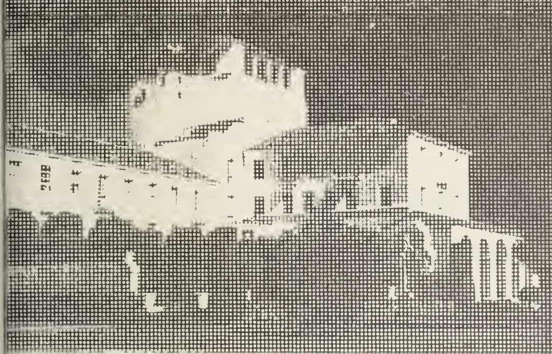
NAVAL POSTGRADUATE SCHOOL

CATALOG

ACADEMIC YEAR 1986



NAVAL POSTGRADUATE SCHOOL

CATALOG
ACADEMIC YEAR 1986

MISSION

To conduct and direct the advanced education of commissioned officers, and to provide such other technical and professional instruction as may be prescribed to meet the needs of the naval service; and in support of the foregoing, to foster and encourage a program of research in order to sustain academic excellence.

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ACADEMIC CALENDAR

Fall Quarter AY '86

Reporting Date	Monday, 23 September 1985
Instruction Begins	Tuesday, 1 October
Columbus Day *(Holiday)*	Monday, 14 October
Reporting Date for Refresher	Thursday, 7 November
Veterans Day *(Holiday)*	Monday, 11 November
Refresher Begins	Tuesday, 12 November
Thanksgiving Day *(Holiday)*	Thursday, 28 November
Quarter Final Exams	Monday - Thursday, 16-19 December
Graduation Exercises	Thursday, 19 December

Winter Quarter AY '86

Reporting Date	Monday, 30 December 1985
New Year's Day *(Holiday)*	Wednesday, 1 January 1986
Instruction Begins	Monday, 6 January
Martin Luther King's Birthday	Monday, 20 January
Reporting Date for Refresher	Thursday, 13 February
Washington's Birthday *(Holiday)*	Monday, 17 February
Refresher Begins	Tuesday, 18 February
Quarter Final Exams	Monday - Thursday, 24-27 March
Graduation Exercises	Friday, 28 March

Spring Quarter AY '86

Reporting Date	Monday, 24 March, 1986
Instruction Begins	Monday, 31 March
Reporting Date for Refresher	Thursday, 8 May
Refresher Begins	Monday, 12 May
Memorial Day *(Holiday)*	Monday, 26 May
Quarter Final Exams	Monday - Thursday, 16-19 June
Graduation Exercises	Friday, 20 June

Summer Quarter AY '86

Reporting Date	Monday, 30 June, 1986
Fourth of July *(Holiday)*	Friday, 4 July
Instruction Begins	Monday, 7 July
Reporting Date for Refresher	Thursday, 14 August
Refresher Begins	Monday, 18 August
Labor Day *(Holiday)*	Monday, 1 September
Quarter Final Exams	Monday - Thursday, 22-25 September
Graduation Exercises	Friday, 26 September

Fall Quarter AY '87

Reporting Date	Wednesday, 24 September 1986
Instruction Begins	Wednesday, 1 October
Columbus Day *(Holiday)*	Monday, 13 October
Reporting Date for Refresher	Thursday, 6 November
Refresher Begins	Monday, 10 November
Veterans Day *(Holiday)*	Tuesday, 11 November
Thanksgiving Day *(Holiday)*	Thursday, 27 November
Quarter Final Exams	Monday - Thursday, 15-18 December
Graduation Exercises	Thursday, 18 December

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"...I consider the investment in graduate education of selected officers to be a strategic requirement for the Navy. With today's technological, managerial and political/economic complexities the need for graduate-level expertise has never been greater. Educating officers in specific subspecialties greatly increases operational readiness and, as a corollary benefit, develops the intellectual diversity and capacity, which enhances the total professional performance of our officer corps. Our investment in graduate education must be pursued with priority even in the face of competing demands..."

"...Graduate education will be provided to selected officers who have demonstrated superior professional performance and who possess the academic capability to complete successfully graduate studies. To ensure the proper flow of top performers into graduate education each community must encourage its best officers to participate. Annual inputs will reflect an equitable distribution among academic disciplines and officer year groups. Annual inputs will ensure an adequate inventory of subspecialists with advanced degrees to support billet requirements. To achieve this required steady-state inventory, twenty percent of our officer corps will need graduate level subspecialty qualifications..."

JAMES D. WATKINS
CHIEF OF NAVAL OPERATIONS

Superintendent

Robert H. Shumaker,
Rear Admiral, U.S. Navy
B.S., U.S. Naval Academy, 1956
B.S. in Aeronautics, Naval Postgraduate School, 1963; M.S. in Aeroelectronics, 1965; M.S. in Electrical Engineering, 1975; Ph.D. in Electrical Engineering, 1977

Academic Dean

David Alan Schrady
B.S., Case Institute of Technology, 1961; M.S., 1963; Ph.D., 1965

BOARD OF ADVISORS

The NPS Board of Advisors is composed of distinguished professionals from a wide variety of backgrounds and view points. The Board visits the campus annually to examine educational programs and facilities, review new initiatives and policies, and provide counsel and recommendations.

Mr. Robert Ballard, Senior Scientist, Oceanography, Woods Hole, MA
The Honorable Jack Borsting, Dean, School of Business, University of Miami.
Mr. Edwin J. Feulner, Jr., The Heritage Foundation, Washington, D.C.
Mr. Robert R. Fossum, Dean of Engineering, Southern Methodist Univ., Dallas, TX.
Brigidier General James D. Hittle, USMC, (Ret)
Mrs. Nancy Kissinger, International Affairs, Washington, D.C.
Mr. Thomas Landin, Communications, Smithkline Beckman Corp., Philadelphia, PA
Mr. Alvin Mandell, Aerospace, Bedford, MA
The Honorable Gale McGee, President of McGee & Associates, Washington D.C.
Mr. David Packard, Military/Industrial Relations, Palo Alto, CA
Dr. David S. Potter, Vice President, Public Affairs Group, General Motors Corporation
General John W. Vogt, USAF (Ret)
Admiral Alfred J. Whittle, Jr., USN, (Ret)

ADMINISTRATIVE STAFF

DIRECTOR OF PROGRAMS, **J.W. Egerton;** Captain, U.S. Navy; B.S., USNA, 1956; M.S., Naval Postgraduate School, 1967.

DIRECTOR OF MILITARY OPERATIONS, **James E. Bley, Jr.,** Captain, U.S. Navy; A.B.; Clark Univ., 1954.

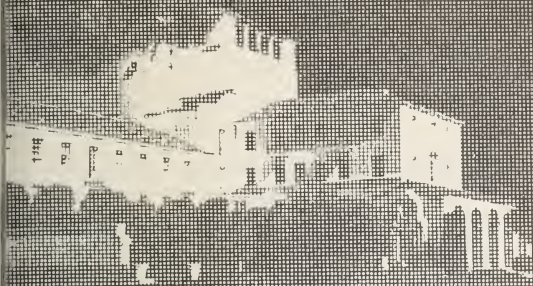
DEAN OF EDUCATIONAL DEVELOPMENT, EXECUTIVE DIRECTOR, OFFICE OF CONTINUING EDUCATION, **Walter Max Woods;** B.S., Kansas State Teachers College, 1951; M.S., Univ. of Oregon, 1957; Ph.D., Stanford Univ., 1961.

DEAN OF ACADEMIC ADMINISTRATION, **Gerald Herbert Lindsey;** B.E.S. in M.E., Brigham Young Univ., 1960; M.S., 1962; Ph.D., California Institute of Technology, 1966.

DEAN OF INFORMATION AND POLICY SCIENCE, **Kneale Thomas Marshall;** B.Sc Imperial College, 1958; M.S., Univ. of California at Berkeley, 1964; Ph.D., 1966.

DEAN OF SCIENCE AND ENGINEERING, **John Norvell Dyer;** B.A., Univ. of California at Berkeley, 1956; Ph.D., 1960.

GENERAL INFORMATION



HISTORY

The Naval Postgraduate School is in its 77th year of operation. The development of a naval institution of higher learning dedicated to the advanced education of commissioned officers began on 9 June 1909 when the Postgraduate Department of the U.S. Naval Academy was established at Annapolis. Ten officers made up the first class, three professors formed the faculty, and marine engineering was the one course of study.

The School closed during World War I, but classes resumed in 1919. In ensuing years, the School grew in size and scope as its educational offerings were more comprehensively directed towards the broad military applications of science and technology. The postgraduate department was renamed the United States Naval Postgraduate School, but still operated as a part of the Naval Academy. In 1927, the General Line Course was established to acquaint junior line officers with modern developments within the Navy and to broaden their professional knowledge of future command at sea.

With the advent of World War II, the School's activities increased substantially. There was a large growth in student enrollment and educational programs were expanded to meet the evolving needs of the Navy. Following the end of the War, plans were initiated to move the School to more suitable facilities and to enhance its academic status.

Between 1945 and 1948, Congress established the School as a separate activity under its own Superintendent, created the office of Academic Dean and granted the Superintendent the authority to award the bachelor's, master's and doctor's degrees. It also approved Monterey as the future home of the School. The General Line School, closed during the war years, was reestablished at Monterey and at Newport, Rhode Island.

After purchasing the former Del Monte Hotel and surrounding acreage, the Navy officially established the School on the West Coast on 22 December 1951. With its enlarged facilities, the School continued to grow in curricular programs and in student enrollment. In 1956, the Navy Management School was formed as a component of the Postgraduate School to provide graduate education in the theory and application of administrative science. In 1958, the General Line School was renamed the General Line and Naval Science School, and a Bachelor of Science curriculum was offered to selected officers who had not completed their undergraduate education. A further need for baccalaureate courses resulted in the inauguration of the Bachelor of Arts curriculum in 1961.

A major internal reorganization of the School was authorized in 1962. The Management, Engineering, and General Line School merged, making the Naval Postgraduate School in effect, a naval university, unified in policies, procedures and objectives.

In 1973, the Naval Postgraduate School, together with the Naval War College and the U.S. Naval Academy, was made a component of the Naval Education and Training Command located at Pensacola, Florida.

Since 1946, the School has awarded over 6,000 bachelor's degrees and more than 13,000 graduate degrees. At the present time, the total educational emphasis is on graduate-level programs.

Currently, the Naval Postgraduate School occupies an attractive and well-appointed campus, graduates approximately 800 students per year and offers a range of curricular programs specifically tailored to impart the scientific, engineering, operational and administrative knowledge required to meet the present and projected professional needs of the Department of Defense. Its student body includes officers of all five U.S. services and approximately 25 allied services. U.S. Naval Officers constitute 60% of the student body, with 23% coming from other U.S. Services. The remaining 17% is made up of foreign officers. Also, since 1975, the Postgraduate School has enrolled civilian employees of the U.S. federal government.

ORGANIZATION AND FUNCTIONS

The Superintendent of the Postgraduate School is a flag officer of the line of the Navy. His principal assistants are a Provost/Academic Dean who is the senior member of the civilian faculty; and two captains of the line — a Director of Programs, and a Director of Military Operations

The academic programs and direct supporting functions are administered and operated through a unique organization composed of Curricular Offices and Academic Departments. The former are staffed by naval officers and civilian faculty members whose primary functions are threefold: (1) academic counseling and military supervision of officer students; (2) curriculum development and management to insure attainment of professional and academic objectives; and (3) liaison with curricular sponsor representatives. Officer students in each curricula group pursue similar or closely related curricula.

Officer students are grouped into the following curricular program areas:

Administrative Science
Aeronautical Engineering
Air-Ocean Sciences
Antisubmarine Warfare
Command, Control and
  Communications (C3)
Computer Technology
Electronics and Communications
National Security Affairs/
  Intelligence
Naval Engineering
Operations Analysis
Weapons Engineering/ASW

The teaching functions of classroom and laboratory instruction and thesis supervision are accomplished by a faculty which is organized into eleven academic departments and three interdisciplinary groups:

Administrative Sciences
Aeronautics
ASW Group
Command, Control and
  Communications (C3) Group
Computer Science
Electrical and Computer Engineering
Electronic Warfare Group
Mathematics
Mechanical Engineering
Meteorology
National Security Affairs
Oceanography
Operations Research
Physics

Over 80% of the teaching staff are civilians of varying professional rank and the remainder are military officers.

The academic program organization is supervised by the Director of Programs, the Dean of Information and Policy Sciences, and the Dean of Science and Engineering who collaborate to share jointly the responsibilities for planning, conduct and administration of the several education programs.

The close tie between elements of this dual organization is further typified by the role of the Academic Associates. These are individual civilian faculty members who are appointed by the Academic Dean to work closely with the Curricular Officers in the development and continuing monitoring of curricula —the Navy's needs constituting the responsibility of the Curricular Officer, and academic soundness the responsibility of the Academic Associate.

Logistic service support is rendered by conventional departments such as Supply and Public Works grouped organizationally under a Director of Military Operations. Certain other officers such as the Comptroller and Civilian Personnel Officer are directly responsible to the Superintendent in a slightly modified but typical naval staff organization.

STUDENT AND DEPENDENT INFORMATION

Monterey Peninsula and the cities of Monterey, Carmel, Pacific Grove, and Seaside, all within 5 miles of the School, provide community support for the students of the Postgraduate School.

LaMesa Village, located 3 miles from the School, consists of former Wherry Housing, Capehart Housing and Townhouses. There are a total of 877 units of public quarters for officer students. An elementary school is located within the housing area. Limited housing for unaccompanied students is available in BOQ quarters located on the main campus in Herrmann Hall.

Students services include a campus branch of Bank of America, Navy-Federal Credit Union, U.S. Post Office, Student Mail Center, Navy Exchange, and a child care center. A large commissary is located at Fort Ord and is available to Navy personnel.

Medical facilities include a Dispensary, supported by the U.S. Army Hospital at Fort Ord (7 miles away), and the U.S. Navy Hospital at Oakland (120 miles away). A Dental Clinic is located on campus in Hermann Hall.

The center of campus social activity is the Commissioned Officers and Faculty Club, located in the old hotel building. Two beautiful chapels are also located on the main campus.

Student wives and wives of allied officers may be active in the Officer Students Wives Club, the International Wives Club, and a Little Theater group which puts on three productions a year.

Recreational facilities include a swimming pool, an 18-hole golf course, tennis and badminton courts, basketball and volleyball courts, a softball diamond, picnic grounds, driving range, and gymnasium. Other organized recreational activities are provided by the Ladies Golf Association, Mens Golf Association, Soccer Club, Rugby Club, Lacrosse Club, Karate Club, Tennis Club, and basketball and softball teams. The School also has a very active Military Amateur Radio Station and a Navy Flying Club.

Personnel assigned to the Postgraduate School have an active Sailing Association open to sponsors and their dependents as well as members of the faculty. Sailing conditions are among the finest on the West Coast with excellent weather normally prevailing from February through November. The School's recreation department schedules the two Shields Class Racing Sloops, two Santana-22s, two Columbia 22s and one 40 foot launch on a first-come first-served basis. Classes for beginners and advanced sailing enthusiasts are conducted quarterly, following each student input. The School works closely with civilian yacht clubs to coordinate many sailing events throughout the year and, in addition, hosts the annual Navy West Coast Match racing championships.

ADMISSIONS PROCEDURES

U.S. NAVAL OFFICERS

U.S. Navy officers interested in attending one of the curricula offered at the Naval Postgraduate School are referred to **OPNAVINST 1520.23** and to the latest **OPNAVNOTE 1520.** These documents provide information, policy, and procedural guidance for the Navy's graduate education program. Included is material concerning officer eligibility criteria for consideration, curricula available at the School and other institutions, academic prerequisites, and instructions for maintaining

up-to-date transcript files and submitting curricular preferences and other requests concerning graduate education.

The Graduate Education Selection Board is convened annually by the Commander, Naval Military Personnel Command, to select officers from specified year-groups for Navy-Funded graduate education within quotas reflecting the Navy's requirements in the fields of study available. Selection is based on an officer's demonstrated professional performance and prior academic background. Selectees are notified by official correspondence at the earliest feasible date after the Board meets.

Officers' chances for selection are enhanced if they have completed recommended preparatory courses for their preferred programs. Appropriate courses for individual self-study are available from the Naval Postgraduate Continuing Education Program, described in a following section of this catalog.

ACADEMIC PROFILE CODE (APC)

The Academic Profile Code (APC) is a three-digit number that summarizes pertinent portions of a Naval officer's prior college performance and is an important factor in the Navy's graduate education selection process. The Naval Postgraduate School computes APC's within two years after commissioning for officers of most Navy communities. A detailed description of the APC system is also found in OPNAVNOTE 1520. Briefly, the three independent digits reflect an individual's cumulative grade-point average (QPR), performance in calculus-related mathematics courses, and qualifications in selected science/engineering areas. The following paragraphs pro-

The first digit is derived from the following:

Code	QPR Range
0	3.60-4.00
1	3.20-3.59
2	2.60-3.19
3	2.20-2.59
4	1.90-2.19
5	0-1.89

(Failures and repeated courses are included in the QPR calculation.)

The second digit (Mathematics Code) is based on the following criteria:

Code	Meaning
0	Significant post-calculus math with B or better average
1	Calculus sequence completed with B+ or better average
2	Calculus sequence completed with average between C+ and B
3	One calculus course with C or better
4	Two or more pre-calculus courses with B or better average
5	One pre-calculus course with C or better grade
6	No pertinent college-level math with C or better grade

The third digit (Technical Code) is based on qualifications for the technical curricula at the Naval Postgraduate School:

Code	Meaning
0	Significant pertinent upper-division technical courses with B+ or better average
1	Significant pertinent upper-division technical courses with average between C+ and B
2	Complete calculus-based physics sequence with B+ or better average
3	Complete calculus-based physics sequence with average between C+ and B
4	One calculus-based physics course with C or better grade
5	No pertinent technical courses

(A Technical Code of 1 or 0 ordinarily is assigned only to an officer whose undergraduate major was Physics or Aeronautical, Electrical, or Mechanical Engineering. Exceptions are made for those desiring to attend civilian colleges for studies in other technical areas; for example, officers of the Civil Engineering Corps. Officers in this catagory, other than CEC members, should contact the Director of Admissions of the Naval Postgraduate School for re-evaluation of their Tech Codes.)

For example, an APC of 221 indicates a total grade average for all college courses in the interval 2.60-3.19, a complete sequence in calculus-of-one-variable with a C+ or B average, and a major in physics or pertinent engineering area with upper-division courses with a C+ or B average.

Each curriculum at the Naval Postgraduate School has a specified threshold APC for admission. Officers with deficient APC's can qualify for entry into these curricula by completing suitable courses from the School's Continuing Education Program or at any accredited civilian college. Transcripts (not grade reports) of work done at civilian schools must be forwarded to the Director of Admissions, Code 0145, Naval Postgraduate School, Monterey, CA 93943, to effect an APC change. The grades in all courses completed will be used to revise an officer's QPR. Only courses with B or better grades are used to upgrade either a Math Code or Tech Code. The following table lists the sequences of self-study minicourses available from the school that must be completed to upgrade selected Math or Tech Code digits to lower ones. The number of courses required in each case is determined by the subject coverage needed.

MATHEMATICS CODE (Second Digit)

Existing Code	Desired Code	Self-Study Courses Required
6	5	MA 1131
5	4	MA 1132
4	3	MA 1133,34
3	2	MA 1135,36

TECHNICAL CODE (Third Digit)

Existing Code	Desired Code	Self-Study Courses Required
5	4	PH 1061-63
4	3	PH 1064-66

OTHER U.S. MILITARY OFFICERS

Officers on duty with other branches of service are eligible to attend the Postgraduate School. Requests for admission or transcripts from individual officers should **not** be sent directly to the Naval Postgraduate School. They should apply in accordance with the directives promulgated by the Department of the Army, Department of the Air Force, Commandant U.S. Marine Corps, or the Commandant U.S. Coast Guard, as appropriate.

ALLIED COUNTRY MILITARY OFFICERS

Military officers from Allied countries may be admitted to most curricula. Their admission is subject to availability of quotas assigned to each country. The procedures for application are contained in **OPNAV INSTRUCTION 4950.1E.** Correspondence must be processed through normal channels; requests from individual officers should **not** be sent directly to the Naval Postgraduate School. In addition to fluency in English, candidates must satisfy the academic standards for each curriculum as described in this catalog.

CIVILIAN EMPLOYEES OF U.S. GOVERNMENT

A civilian employee of an agency of the United States Federal Government may be admitted for study upon request and sponsorship of the agency. Federal civilian employees are not required to pursue the curricula designed for officer-students as described in this catalog but instead determine, with the guidance of assigned academic counselors, the combination of courses that will best meet their needs.

A civilian who is expecting agency sponsorship should submit a written request for evaluation for admission at least four months prior to expected commencement of studies. A request should indicate the academic area of interest and degree intentions and be accompanied by a complete set of official transcripts of all previous college work. GRE and/or GMAT scores are not required but will be considered when included in the submission.

Requests for admission should be directed to the Director of Admissions, Code 0145, Naval Postgraduate School, Monterey, CA 93943. Questions about available programs or admission procedures may be telephoned to (408) 646-3093 or Autovon 878-3093.

TRANSFER OF CREDITS

Upon entry to the Naval Postgraduate School, each student's academic record will be evaluated for possible transfer of credit or for exemption from portions of the curricular program by validation of course work previously completed. Students may also utilize knowledge gained through self-study, experience or service-related education to seek validation or credit for curricular courses by taking a departmental examination.

Twelve hours of graduate-level courses previously completed may be accepted for transfer credit. These include graduate-level courses taken after completion of the baccalaureate degree and those taken in the last term before award of the baccalaureate and certified to be in excess of degree requirements.

Questions on transfer credit may be directed by letter to the Dean of Academic Administration, Code 014, Naval Postgraduate School, Monterey, CA 93943, or telephone (408) 646-2391 or Autovon 878-2391.

DEGREES, ACCREDITATIONS, AND ACADEMIC STANDARDS

The Superintendent is authorized to confer Bachelor's, Master's, Engineer's or Doctor's degrees upon qualified graduates of the School. The authority is subject to such regulations as the Secretary of the Navy may prescribe, contingent upon due accreditation from time to time by the appropriate professional authority of the applicable curricula. Recipients of such degrees must be found qualified by the Academic Council in accordance with prescribed academic standards.

The Naval Postgraduate School is accredited by the Accrediting Commission for Senior Colleges and Universities of the Western Association of Schools and Colleges. Engineering curricula accredited by the Accrediting Board for Engineering and Technology (ABET) are Aeronautical, Electrical and Mechanical. Degrees offered in Engineering Science and Engineering Technology are not accredited. The Administrative Science Curricula meets the standards of the National Association of Schools of Public Affairs and Administrators.

The Postgraduate School operates under a quarter system, with each term of instruction lasting 12 weeks. The last week of each quarter is set aside for examinations. In addition, there are two 2-week recesses during the academic year, one over Christmas and one during June-July.

Student academic performance is evaluated in terms of quality points assigned to the letter grade achieved in a course. Based on the level of achievement associated with each letter grade, the corresponding quality point values range from a maximum of 4 to a minimum of 0 as follows:

Grade	*Point Value*
A	4
A-	3.7
B+	3.3
B	3
B-	2.7
C+	2.3
C	2
C-	1.7
D+	1.3
D	1
X	0
*WX	0

**Withdrew Failing*

Letter designations for which no quality points are assigned include the following:

I	Incomplete
W	Withdrew Passing
N	Ungraded
P	Pass
F	Fail

Courses may be designated for P and F grading when approved by the Academic Department and the Academic Council. A student in a non-degree program may elect to receive either the letter grade or the P/F grade in any course in which letter grades are normally assigned. Approval must be granted by the cognizant Curricular Office and/or Department Chairman. It is the responsibility of the student to exercise the P/F option by informing the instructor in writing at the time of enrollment that a P/F grade is desired. Students electing to receive the P/F grade in letter graded courses may not apply the hours toward the degree requirements of any program. A student in a degree program who wishes to take courses not in his normal program may elect to take them in the Pass/Fail mode. Approval must be granted by the student's cognizant Curricular Office and Department Chairman. It is the responsibility of the student to exercise the P/F option by informing the instructor in writing at the time of enrollment that a P/F grade is desired. A copy of the approved request shall be forwarded to the Registrar. Except as provided elsewhere for credit by examination, students electing to receive the P/F grade in letter graded courses may not apply the hours toward the degree and curriculum requirements of any program.

A grade of Incomplete (I), if not removed within twelve weeks following the end of the term for which it was received, will be replaced by the grade "X". Exceptions must be individually approved by the Academic Council.

When the quarter-hour credit of a course is multiplied by the point value of the student's grade, a quality point value for the student's work in the course is obtained. The sum of the quality points for all courses divided by the sum of the quarter-hour credit of these courses gives a weighted numerical evaluation of the student's performance, termed the Quality Point Rating (QPR). A student achieving a QPR of 3.0 has maintained a B average in all courses undertaken with a proper weight assigned for course hours.

Officer students have no major duties beyond applying themselves diligently to their studies. It is expected that students will maintain a high level of scholarship and develop attributes which are associated with a scholar seeking knowledge and understanding. Program schedules are such that the student should anticipate spending several hours in evening study each weekday to supplement time available for study between classes.

DEGREE REQUIREMENTS

Certificates of Completion

Certificates of Completion are issued to students who complete programs but do not qualify for a degree. To establish eligibility for a Certificate of Completion, a student must normally maintain an overall QPR of 2.0 or better.

Requirements for the Master of Arts and Master of Science Degrees

1. The Master's Degree may be awarded for successful completion of a curriculum which has the approval of the Academic Council as meriting the degree. Such curricula shall conform to current practice in accredited institutions and shall contain a well-defined major.

2. General Postgraduate School minimum requirements for the Master's Degree are as follows:
   a. 32 quarter hours of graduate level credits of which at least 20 quarter hours must be earned on campus.
   b. A thesis or its equivalent is required. If the thesis be waived, at

least 8 quarter hours of approved courses 4000-4999 shall be substituted for it.
   c. Departmental requirements for the degree in a specified subject.

3. Admission to a program leading to the Master's degree requires:
   a. A baccalaureate degree or the equivalent.
   b. Appropriate undergraduate preparation for the curriculum to be pursued. If a student enters the Postgraduate School with inadequate undergraduate preparation, he will be required to complete the undergraduate prerequisites in addition to the degree requirements.
   c. A demonstrated academic potential for completing the curriculum.

4. To be eligible for the Master's degree, the student must attain a minimum average quality point rating of 3.00 in all the 3000 and 4000 level courses in his curriculum and either 2.50 in the remaining courses or 2.75 in all courses of the curriculum.

Requirements for the Degree: Engineer

1. The Engineer's Degree typically represents one year of study beyond the Master's Degree. It is awarded for successful completion of a curriculum which has the approval of the Academic Council as meriting the degree.

2. Minimum Postgraduate School requirements for the degree of Engineer are as follows:
   a. 72 quarter hours of graduate level courses including at least 30 hours in courses 4000-4999.
   b. An acceptable thesis.
   c. One academic year in residence.
   d. Departmental requirements for the degree in a specified Engineering field.
   e. A quality point rating of at least 3.00 in all graduate courses in the curriculum and either 2.50 in the remaining courses or 2.75 in all courses of the curriculum.

Requirements for the Doctor's Degree

Any program leading to the Doctor of Philosophy or Doctor of Engineering shall require the equivalent of at least three academic years of study beyond the baccalaureate level, with at least one academic year being spent at the School. A requirement for admission is a Bachelor's degree that includes the prerequisites for full graduate status in the department of his major study.

A general outline of a candidate's progress through the program is as follows:

a. Application to the appropriate department chairman for acceptance.
b. Appointment of the student's doctoral committee, which bears responsibility for the study program and guidance of the research program.
c. Inclusion of one or more minors in the study program.
d. For the Doctor of Philosophy, a foreign language requirement may be included at the discretion of the major department; For the Doctor of Engineering, demonstrated proficiency in computer programming is required.
e. When the study program is essentially finished, successfully complete the qualifying examination, including both oral and written parts.
f. Admission to candidacy and start of work on doctoral dissertation on a subject approved by the doctoral committee.
g. Upon completion of dissertation and acceptance by doctoral committee, administration of final oral examination.
h. Upon unanimous recommendation of doctoral committee, Academic Council makes final decision on recommendation for award of the degree.

ACADEMIC HONORS

GRADUATION WITH HONORS. The award of the Master of Science and the Master of Arts degrees may be made "With Distinction" when a student completes the degree requirements with a minimum of 32-quarter hours earned in residence and is in the upper 10% of the graduating class from the student's department.

ADMIRAL WILLIAM ADGER MOFFETT AWARD. This award is presented annually to an outstanding graduate of the Aeronautical Engineering curriculum. The award is made on the basis of the student's academic excellence, including thesis, and his career potential.

ARMED FORCES COMMUNICATIONS AND ELECTRONICS ASSOCIATION AWARDS. This award is presented to a student who has achieved academic excellence and demonstrated professional qualities in fields of interest to the AFCEA organization. The selection will be made, on a quarterly rotational basis, from among graduates of the Electronics/Communications, C3, Computer Technology, and Naval Intelligence programs, respectively.

CAPTAIN GRACE MURRAY HOPPER COMPUTER TECHNOLOGY AWARD. This award is given annually to two outstanding graduates of the Computer Systems curriculum and one outstanding graduate of the Computer Science curriculum.

CAPTAIN J.C. WOELFEL AWARD. This award is given annually to the United States Naval Officer student receiving an advanced degree in the Naval Engineering Programs who has demonstrated the most outstanding academic record, and at the same time possesses those attributes best exemplifying a Naval Officer.

CHIEF OF NAVAL OPERATIONS AWARD FOR ACADEMIC EXCELLENCE IN ORGANIZATIONAL DEVELOPMENT. This award is given semiannually to a U.S. Navy, or OP-01 sponsored civilian, graduate of the Organizational Development curriculum who has demonstrated the ability to apply organizational development techniques to the improvement of Navy combat readiness and retention and who exhibits qualities of an outstanding naval officer.

CHIEF OF NAVAL OPERATIONS ASW AWARD. This award is given annually to the most outstanding student graduating from the Antisubmarine Warfare curriculum.

CHIEF OF NAVAL OPERATIONS COMMUNICATIONS AWARD. This award is presented semiannually to the graduate in an advanced communications degree program achieving an outstanding academic record and exhibiting those qualities indicative of an outstanding military officer.

CHIEF OF NAVAL OPERATIONS COMMUNICATIONS CERTIFICATE. This certificate is presented quarterly to the Master of Science graduate who shows the greatest academic improvement in a Communications curriculum.

CHIEF OF NAVAL OPERATIONS AWARD FOR EXCELLENCE IN MANPOWER, PERSONNEL AND TRAINING ANALYSIS. This award is given semiannually to a U.S. Navy, or OP-01 sponsored civilian, graduate of the Manpower Personnel Training

Analysis curriculum who has demonstrated outstanding academic performance, thesis quality and leadership potential.

CHIEF OF NAVAL OPERATIONS AWARD FOR EXCELLENCE IN OPERATIONS RESEARCH. This award is presented semiannually to an outstanding United States Navy or Marine Corps graduate of the Operations Research Systems Analysis curriculum. The award is made on the basis of academic record, performance during the student's experience tour, and faculty recommendation.

DIRECTOR OF NAVAL INTELLIGENCE GRADUATION AWARD. This award is presented annually to recognize the most outstanding student in the Naval Intelligence curriculum.

JOINT CHIEFS OF STAFF COMMAND, CONTROL AND COMMUNICATIONS AWARD FOR ACADEMIC ACHIEVEMENT. This award is presented annually to the outstanding graduate of the C3 curriculum. It is made on the basis of academic record, thesis research and faculty recommendations.

MEWBORN STUDENT RESEARCH AWARD. This award affords recognition for exceptional research talent. It is awarded annually to a student in a program of graduate scientific or engineering studies, leading to an advanced degree, whose thesis exhibits sound scholarship and outstanding research ability.

MILITARY OPERATIONS RESEARCH SOCIETY GRADUATE RESEARCH AWARD. This award is given semiannually to a student on the basis of outstanding achievement in graduate research directed toward improving military force utilization.

NAVAL SUPPLY SYSTEMS COMMAND AWARD FOR ACADEMIC EXCELLENCE IN ADMINISTRATIVE SCIENCES. This award is presented annually to the outstanding U.S. Naval Supply Corps Officer graduate of an Administrative Sciences curriculum at the Naval Postgraduate School based on academic record, research excellence, contributions to the professional and civilian communities, and faculty recommendation.

NAVAL ELECTRONIC SYSTEMS COMMAND AWARD IN ELECTRONICS ENGINEERING. This award is given semiannually to a Master of Science candidate in the Advanced Electronics Engineering Program who has a most outstanding academic record and whose qualities indicate an outstanding military officer.

NAVAL ELECTRONIC SYSTEMS COMMAND ELECTRONIC WARFARE TECHNOLOGY AWARD. This award is presented annually to a Master of Science candidate in the Electronic Warfare Systems Technology Program. The award is made on the basis of academic excellence, including the quality and relevance of the thesis, and leadership qualities.

NAVAL SEA SYSTEMS COMMAND AWARD IN NAVAL ENGINEERING. This award affords recognition to a graduate of any curriculum leading to a Master of Science degree in Mechanical or Electrical Engineering who has demonstrated academic excellence through attainment of a high Quality Point Rating in addition to an outstanding thesis, and who has exhibited leadership potential in the engineering area.

NAVAL SEA SYSTEMS COMMAND AWARD IN WEAPONS ENGINEERING EXCELLENCE. This award is given annually to the most outstanding officer graduate of the Weapons Systems Engineering curricula.

NAVAL UNDERWATER SYSTEMS CENTER AWARD FOR EXCELLENCE IN UNDERWATER SYSTEMS TECHNOLOGY. This award is given annually to the student graduate who by academic standing and relevance of thesis topic has demonstrated the greatest contribution in the field of Underwater Systems Technology.

NAVAL LEAGUE OF MONTEREY AWARD FOR HIGHEST ACADEMIC ACHIEVEMENT. This award is presented quarterly to the graduating U.S. Navy, Marine Corps or Coast Guard officer who has maintained the highest academic grade average as a student at the Naval Postgraduate School.

OCEANOGRAPHER OF THE NAVY AIR-OCEAN SCIENCE AWARD. This award is presented annually to a U.S. Navy officer graduate of the Air-Ocean Science program who has demonstrated outstanding academic performance and has exhibited those qualities indicative of an outstanding military officer.

REAR ADMIRAL THOMAS R. McCLELLAN AWARD. This award is presented quarterly to a graduate of any Administrative Science curriculum who has demonstrated excellence in all facets of Management. The recipient is judged on personal leadership, professional commitment, and intellectual achievement.

SIGMA XI. The Naval Postgraduate School has a Chapter of the Society of the Sigma XI, an honorary society founded to recognize excellence in the scientific and engineering disciplines. Students who have demonstrated marked promise in their research work are considered for membership each year. The number elected is limited only by the quality of the research work done for a graduate degree.

U.S. ARMY TRAINING & DOCTRINE COMMAND AWARD FOR ACADEMIC EXCELLENCE IN OPERATIONS RESEARCH. This award is given semiannually to the outstanding U.S. Army student in the Operations Analysis Program.

UNITED STATES NAVAL INSTITUTE AWARD. This award is presented quarterly to that recipient of a Master's Degree in National Security Affairs whose achievement has significantly advanced professional, literary or scientific knowledge in the naval or maritime services.

W. RANDOLPH CHURCH AWARD. This award is given annually to a student on the basis of his performance in mathematics courses. The criteria for selection will include evidence of initiative, scholarly attitude and mathematical maturity. The student need not be a mathematics major, nor must he be a graduate at the time of presentation.

PROFESSIONAL SOCIETIES

Students have the opportunity to attend many professional meetings held at the Naval Postgraduate School. Several local chapters provide for student membership. These include Eta Kappa Nu, Sigma Xi, Tau Beta Pi, as well as ACM (Association for Computing Machinery), AIAA (American Institute of Aeronautics and Astronautics), AMS (American Meteorological Society, ASME (American Society of Mechanical Engineers), ASNE (American Society of Naval Engineers), IEEE (Institute of Electrical and Electronics Engineers, Inc.), ORSA (Operations Research Society of America), the Marine Technology Society, AFCEA (Armed Forces Communications and Electronics Association), NCMA (National Contract Management Association), and ASMC (American Society of Military Controllers).

SUPERINTENDENT'S GUEST LECTURE PROGRAM

On several occasions during the year, special lectures are presented for students, faculty and staff in the King Hall Auditorium. Eminently qualified civilians such as Dr. Alton Frye, Washington Director and Senior Fellow of the Council on Foreign Relations and Director of the Group on Strategic Studies; Ambassador V.A. Walters; and Dr. Robert A. Frosch, Charles Davis Lecturer, speak on subjects of current interest, which cover a wide range of fields. Military authorities, such as Admiral James D. Watkins, Chief of Naval Operations; Vice Admiral Joseph Metcalf, III, Commander Second Fleet; and Admiral Thomas B. Hayward, retired Chief of Naval Operations, speak on matters of current and historical interest in international, military and governmental affairs. The primary purpose of this series is to inform as well as to stimulate and challenge the thinking of the officer students in areas outside of their immediate academic pursuits. Occasionally, speakers are presented in the evenings with wives also invited to attend.

NAVAL POSTGRADUATE SCHOOL FOUNDATION

The Foundation is a nonprofit corporation whose purposes are:

> "to solicit, receive, and administer contributions and make donations and dispense charitable contributions ... and otherwise aid, encourage and support the traditions of the Naval Postgraduate School ...."

The corporation was formed in December 1970, and has since served as a vehicle by which tax-exempt gifts have been given to the School. These gifts are all applied to those needs or purposes which would otherwise be poorly funded or not funded at all.

Individuals wishing to participate in the work of the Foundation may write to the Secretary, Naval Postgraduate School, Monterey, California 93943.

FEDERAL CIVILIAN EDUCATION PROGRAM

Any civilian employee of the United States government is eligible to participate in the program of the School. The individual's employing agency is expected to meet the tuition expense for regular on-campus enrollment ($1000 per quarter per student for FY 1985). Costs associated with participation in the Continuing Education Program are determined on an ad hoc basis.

Programs available to civilian students can be classified as follows:

Regular Curricula. The School's programs for officers are designed to meet the requirements of the services for specific education. The contents usually exceed the requirement for a graduate degree since the service's requirements, rather than degree requirements, determine the scope of each program. Civilian students may enter any curriculum at the point at which they are qualified and complete the curriculum along with regular officer students. The School Catalog, available upon request, describes the available curricula.

Degree Programs. For civilian students, programs can be designed which lead to the award of a graduate degree in a minimal time while meeting the educational goals of each individual. In order to minimize the residency requirement, an off-campus preparatory program may be developed in consultation with a School advisor. This may include self-study courses from the School or courses at a local university. If the available time in residence, typically four calendar quarters or less, is insufficient to complete degree requirements, the thesis-project portion of the program may be completed off-campus.

Degree programs available include Master of Arts in National Security Affairs; Master of Science with Major in Mathematics; and Master of Science degrees in Aeronautical Engineering, Applied Mathematics, Applied Science,

Computer Science, Electrical Engineering, Engineering Acoustics, Engineering Science, Hydrographic Sciences, Information Systems, Management, Material Science,Mechanical Engineering, Meteorology, Meteorology and Oceanography, Oceanography, Operations Research, Physics, Systems Technology (Command, Control and Communications) or (Antisubmarine Warfare), and Telecommunications Systems Management.

Engineer degree programs are available in Aeronautical, Electrical, and Mechanical Engineering. Doctor of Engineering degrees are available in Aeronautics, Electrical Engineering, Mechanical Engineering, and Electrical Engineering/Physics (Engineering Acoustics).

The Doctor of Philosophy degree is given in Aeronautics, Computer Science, Electrical Engineering, Electrical Engineering/Physics (Engineering Acoustics), Mechanical Engineering, Meteorology, Oceanography, Operations Research, and Physics.

Non-Degree Programs. Civilian employees may desire to pursue a program for professional advancement without a degree objective. Any of the School's regular courses are available for such efforts. For groups of employees from an agency, special courses can be offered to meet particular requirements, provided the demand is in an area of expertise of the School.

Continuing Education. Approximately thirty-five short courses are delivered annually, both on-site at supporting activities and at Monterey. Attendance in these courses is open to military and civilian employees of the Federal Government. Courses given at Monterey are offered on a tuition-fee basis. A listing of planned short courses is available upon request. Civilian employees of the Federal Government may also enroll in self-study courses which can be completed off-campus for academic credit with assistance of an on-site tutor. Courses completed in this manner prior to beginning a degree program at NPS can reduce time in residency. Until further notice, no fee is charged for civilian enrollments in self-study courses. A listing of available courses, enrollment procedures, and other details of this program are provided in the Catalog of Self-Study Credit Courses, which is available at all ships and stations in the Navy. Copies of this catalog are available upon request.

There are no formal requirements for enrollment in the Continuing Education Program or for a non-degree program. For admission to a program leading to a graduate degree, the minimum qualification is an accredited baccalaureate degree with appropriate preparation for the proposed degree program. As described under Admissions Procedures in this Catalog, the School will require submission of official transcripts covering all college work completed to date.

The point of contact for requests for Naval Postgraduate School Catalogs: Dean of Academic Administration, Code 014, Naval Postgraduate School, Monterey, CA 93943; or telephone (408) 646-2391 or Autovon 878-2391. Requests for information about on-campus programs or admission to degree programs: Director of Admissisons, Code 0145, Naval Postgraduate School, Monterey, CA 93943; or telephone (408) 646-3093 or Autovon 878-3093. Requests for a listing of planned short courses or Catalog of Self-Study Courses: Director of Continuing Education, Code 500, Naval Postgraduate School, Monterey, CA 93943; or telephone (408) 646-2558 or Autovon 878-2558.

CONTINUING EDUCATION PROGRAM

The Naval Postgraduate School Continuing Education Program was established in June 1974 as a means of providing extended educational services that will more comprehensively fulfill the school's assigned mission. These extended services include the offerings of self-study credit courses off campus; the delivery, both on and off campus, of professionally relevant short courses; and expanded educational counseling. The self-study credit course offerings are listed in the Catalog of Self-Study Courses which is distributed annually to nearly all ships and stations in the Navy and to selected offices of other DoD establishments. This program is administered by the Continuing Education Office.

Selected graduate preparatory courses are delivered off campus in a self-study self-paced mode for the same academic credit as received when taken on campus. These self-study courses are delivered to officers at their current duty stations for completion during off-duty hours. They have been selected from courses normally taken in the initial phase of curricular programs at the Naval Postgraduate School. Their successful completion will enhance selection for postgraduate education, enhance performance in early phases of graduate education programs, and reduce course requirements in curricular programs at the Naval Postgraduate School. The delivery of a self-study credit course normally requires the local participation of a qualified tutor (e.g., a civilian or officer with requisite graduate education). Self-study courses taken for review do not require a tutor.

Application for enrollment in a self-study course may be made at any time. Applicants should use the appropriate form contained in the self-study catalog. Self-study courses are also available to civilian employees of the federal government.

Commands with available funds may arrange for delivery on site of short courses to meet specific needs on a direct reimbursable basis to the Naval Postgraduate School. Delivery costs may be obtained from the Continuing Education Office.

More information on short courses and self-study courses is available from the Continuing Education Office, Code 500, Naval Postgraduate School, Monterey, CA 93943, or telephone (408) 646-2558 or autovon 878-2558.

ACADEMIC COUNSELING SERVICE

The Naval Postgraduate School offers academic counseling from several offices to assist in developing individual educational plans. Prospective students who have chosen specific curricula, or who have been selected or detailed for graduate education in curricular programs at the Naval Postgraduate School should direct inquiries to the appropriate curricular office. Specifically, requests for names of courses that can be taken in a self-study mode to prepare for curricula of interest at the Naval Postgraduate School should be directed to the appropriate curricular officer. Curricular office telephone numbers and mailing codes are listed in the "Curricular Offices and Programs" section of this catalog.

Officers seeking general information about sub-specialty codes, selection for graduate education, and preliminary information about graduate education commensurate with career fields should contact the Director of Counseling in the Office of Continuing Education, Code 500, Naval Postgraduate School, Monterey, CA 93943, or telephone (408) 646-2984 or Autovon 878-2984.

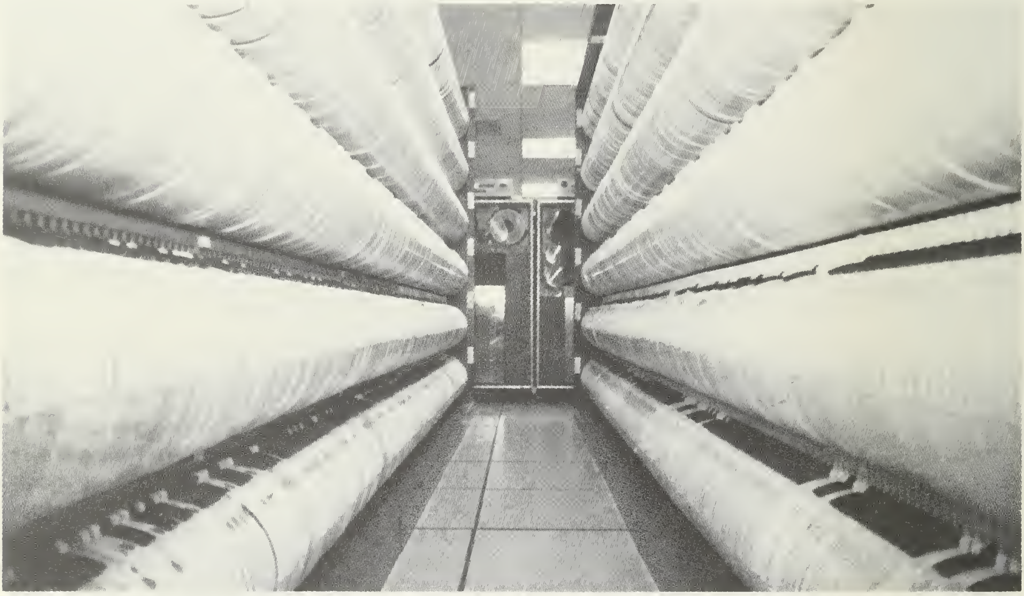
The Naval Postgraduate School has been assigned the responsibility of preparing an abstract of the academic background of each newly-commissioned officer of most U.S. Navy communi-

ties. From this abstract, a three-digit Academic Profile Code (APC) is developed, summarizing the officer's pertinent academic qualifications. The APC is used by the Naval Selection Board that nominates officers for Navy-funded graduate education. Officers can improve their APC's by completing additional college-level courses. Appropriate courses completed through the Naval Postgraduate School Self-Study Program are utilized to upgrade APC's. Officers who complete courses from other institutions should forward transcripts (not grade reports) to the Director of Admissions, Code 0145, Naval Postgraduate School, Monterey, CA 93943, in order to maintain complete academic records and accurate APC's. Officers seeking information concerning their APC's, their academic qualifications for curricula at the School, or the status of their transcript files at the school should contact the Director of Admissions by telephone at (408) 646-3093 or Autovon 878-3093 or by writing to the above address.

Inquiries pertaining to funded curricula not offered at the Naval Postgraduate School and to doctoral programs at the Naval Postgraduate School or elsewhere should be directed to Manager, Civilian Institutions Program, Naval Postgraduate School, Monterey, CA 93943, or telephone (408) 646-2319 or Autovon 878-2319.

COMPUTER FACILITIES

W.R. CHURCH COMPUTER CENTER



STAFF

Douglas George Williams, Professor and Director (1961)*; M.A. (Honours), Univ. of Edinburgh, 1954.

Roger Rene Hilleary, Manager, User Services (1962); B.A., Pomona College, 1953; M.S., Naval Postgraduate School, 1970.

David Fredric Norman, Manager, Systems Support Group (1969).

Edwin Vincent Donnellan, Manager, Computer Operations (1966).

Alyce Louise Austin, Systems Support Group (1977); B.S., Naval Postgraduate School, 1981.

Patricia Jacqueline Collins, User Services (1983); B.S., Univ. of California at Santa Barbara, 1983.

Richard Eugene Donat, Systems Support Group (1968); B.S., California Polytechnic State Univ., 1967.

June Ann Favorite, User Services Group (1983); A.S., Monterey Peninsula College, 1978.

Laurence Martin Frazier, User Services Group (1981); B.F.A., San Francisco Art Inst., 1970; B.S. Univ. of California at Santa Cruz, 1980.

Neil Edward Harvey, User Services Group (1980); B.S., The Citadel, 1962.

Kathleen A. Knight, Administrative Asst., (1984).

Stephan Lamont, User Services Group (1983).

Dennis Ronald Mar, User Services Group (1980); B.A., Univ. of California at Berkeley, 1968; M.S., Iowa State Univ., 1970.

Linda Sue Mauck, Systems Support Group (1982); B.A., Univ. of Oklahoma (1968).

Caroline Jennette Miller, Systems Support Group (1975); B.Ed., Univ. of Hawaii, 1966; M.S., Univ. of Rhode Island, 1972.

Ruth Irene Roy, Manager, User Registration and Accounting (1982); B.A., Calvin College, 1968; M.S., Chapman College, 1980.

Deborah S. Walsh, User Registration and Accounting, (1985).

**The year of joining the Postgraduate School is indicated in parentheses.*

The Naval Postgraduate School was one of the first educational institutions to use digital computers in its instructional and research programs. The first machine, an NCR 102A, was installed in 1954 and operated by the Department of Mathematics. A central Computer Facility was created in 1960 as an organizational unit separate from the academic departments. In December, 1969, the Facility was renamed the W. R. Church Computer Center in memory of Professor Church, Chairman of the Department of Mathematics (1947-66), who recognized very early the value of computers in education and was instrumental in obtaining the first computers at the School.

The many services of the Center are available to all faculty, staff, and students of the School for use in instruction, research, or administrative activities.

These services are provided on a multiprocessor hardware configuration consisting of an IBM 3033 Attached Processor (16 megabytes) loosely-coupled with an IBM 3033 Model S (8 megabytes). Both systems have access to all auxiliary storage and the input/output devices including 4 drums with 12 megabytes each as paging devices, 44 IBM 3350-1 disk spindles (317 Mbytes each), 10 IBM 3420-8 tape drives (6250 bpi) and a mass storage system containing cartridges of 50 Mbytes each.

The principal mode of access is via 350 IBM 3278 Display Terminals located in public spaces and private offices in the academic buildings and attached by coaxial cable to the computer in Ingersoll Hall. In addition, there are 20 IBM 3277 APL/Graphic displays available for public use. The computer network is run under the operating system VM/SP (Virtual Machine) which provides batch-processing support on MVS (Multiple Virtual Storage) and interactive computing on CMS (Conversational Monitor System). The extensive programming facilities include VS FORTRAN, WATFIV, VS COBOL, WATBOL, PL/1 Optimizer, BASIC, VS APL, and Pascal. Most languages are available in both interactive and batch-processing modes.

The School has a heavy commitment to computers consistent with their present and future role in military operations. All of the academic curricula have been affected by the presence of computers on campus. The percentage of active student and faculty participation in the computer field is at a level probably unequalled at any other educational institution. All graduate students take at least one course in computer science. They are introduced to computers early in their curricula at the Naval Postgraduate School and encouraged to use them in subsequent course work and research.

The Computer Center supports a wide variety of specialist courses in computer science offered by the Departments of Computer Science, Electrical

& Computer Engineering, Mathematics, Operations Research and Administrative Sciences.

The Center has a staff of 28 people, 13 of whom are involved in programming. The professional staff provides a consulting service in application programming, systems programming and problem formulation to students and faculty members. They participate in an active research and development program directed primarily towards improving the present operational environment or introducing new hardware and software facilities to users. Current projects include work on systems measurement, improvement of operating systems, graphical data processing, time-sharing facilities, micro-to-mainframe communications and networking.

Since 1975 the Center has provided data processing support to the tenant activity, Defense Manpower Data Center (DMDC).

In addition to these facilities, virtually all of the academic departments have developed computing facilities and/or laboratories, mini-and micro-processor based, which provide computing support or are dedicated to specific areas of research. Micro-computers are widely used as stand-alone development tools or as processing elements imbedded in more complex systems. Many students have purchased their own personal computer.

DUDLEY KNOX LIBRARY

STAFF

Paul Spinks, Professor and Director of Libraries (1959)*, B.A., Univ. of Oklahoma, 1958; M.S., 1959.

Mary Therese Britt, Assistant Professor and Associate Director of Libraries (1966); B.S., College of St. Catherine, 1947.

Phyllis Anne Anderson, Acquisitions Librarian (1982); B.S. Univ. of Missouri, 1958; M.S., California State Univ. at San Jose, 1981.

Roberta Marion Carr, Head Cataloging Librarian (1981); B.A., California State Univ. at Sacramento, 1973; M.A., California State Univ. at San Jose, 1976.

Marcia Arline Hellam, Research Reports Technical Information Specialist (1983); B.A., Univ. of California at Berkeley, 1968.

Kenneth Wayne Lauderdale, Head Research Reports Librarian (1981); B.A., Univ. of California at Berkeley, 1949; M.S., 1950.

Kevin John McHugh, Cataloging Librarian (1980); B.A., Loyola Univ., 1948; M.A., 1952; M.S., Univ. of Missouri, 1980.

Roger McQueen Martin, Head Reader Services Librarian (1974); B.S., Univ. of Texas, 1949; M.S., 1958.

Louis Oven, Cataloging Librarian (1969); B.A., Monterey Institute of Foreign Studies, 1964; M.A., Univ. of California at Berkeley, 1968.

Ronald James Rodrigues, Reference Librarian (1984); B.A., California State Univ. at Hayward, 1975; M.L.S., Univ. of California at Berkeley, 1976; B.S., California State Univ. at Hayward, 1978.

Sharon Lee Serzan, Head Acquisitions Librarian (1983); B.A., State Univ. of New York at Albany, 1969; M.S., Rutgers State Univ., Graduate School of Library Service, 1971.

Frances Emanuela Maria Strachwitz, Research Reports Librarian (1970); B.S., Dominican College of San Rafael, 1951; M.A., Univ. of Denver, 1968.

Bryan Paul Thompson, Research Reports Librarian (1981); B.A., Univ. of California at Riverside, 1974; M.S., Univ. of Southern California, 1976.

Ora Mae Wagoner, Assistant Head, Reader Services Librarian (1984); B.A., Spelman College, 1963; M.A., Univ. of Denver, 1973.

**The year of joining the Postgraduate School is indicated in parentheses.*

The Dudley Knox Library, a building of 50,000 square feet, was dedicated in 1972. The collections housed therein serve the research and instructional needs of the community, comprising students, faculty, and staff of all departments of the Postgraduate School. They embrace an active collection of 301,000 books, bound periodicals, government documents, pamphlets, and other materials in hard copy and microform; 515,000 research reports in hard copy and microform; and over 1,700 periodicals and other serial publications currently received. These materials parallel the School's curricular fields of engineering, physical sciences, managerial sciences, operations research, naval sciences, and national security affairs.

The Reader Services Division provides the open literature sources, such as books, periodicals and journals, indexes and abstracting services, pamphlet materials and newspapers. It provides access to more than 250 computer data bases in the curricular fields of interest by means of BRS (Bibilographic Retrieval Services), DIALOG (Lockheed Information Systems, NEXIS (Mead Data Central), and RLIN (Research Libraries Group). It furnishes facilities for microform reading and printing and for reproduction of printed matter. It borrows publications not held in its collections from other libraries.

The Research Reports and Classified Materials Division is the principal repository for research documents received by the School. It houses the Library's classified and unclassified research reports in hard copy and microfiche. A machine information storage and retrieval system that utilizes the School's computer facilities is available for bibliographic searches of research and development documents held by the division. An SDI (Selective Dissemination of Information) Service is also available. The Division is able to perform, via its own remote terminal, computer searches of the data banks of the Defense Technical Information Center in Alexandria, Virginia, and thus to provide rapid and efficient access to the 1,000,000 plus documents held by the Center. It also accesses the CIRC (Central Information Reference and Control) System and NASA/RECON.

The Christopher Buckley, Jr., Library is located on the second floor of the Library. It is a collection of some 8,000 volumes pertaining principally to naval history and the sea.

CURRICULAR OFFICES AND PROGRAMS

The curricular offices are staffed by military Curricular Officers and civilian-faculty Academic Associates. They share the responsibility of developing, maintaining and updating curricular programs that are academically sound and meet the professional needs of the Department of Defense. Each officer student is assigned to an appropriate curricular office for academic and military counseling and supervision.

This section of the catalog includes descriptions of all regularly sponsored curricula offered at the Naval Postgraduate School. Specific academic requirements for enrollment are contained within the portion relating to each curriculum. In general, the more technical curricula require mathematics through calculus and varying levels of scientific or engineering courses.

Students with academic deficiencies in mathematics or science are encouraged to take advantage of the Naval Postgraduate School's Continuing Education offerings. An opportunity also exists for some students to enter an Engineering Science or a Technical Transition Program. These preparatory programs are of one or two quarters in duration. The Engineering Science Program (#460) prepares officers needing specific background for entry into one of the engineering or non-engineering technical curricula. The Technical Transition Program (#465) is designed to prepare naval officers with a weak calculus and/or a weak calculus-based physics background for entry into one of the non-engineering technical curricula.

The curricular programs typically include an introductory phase, wherein a student completes the required preparatory courses before undertaking graduate-level studies. Many of the preparatory courses are available for off-campus self-study through the Office of Continuing Education.

Prospective students are encouraged to communicate with the cognizant Curricular Officer by letter or telephone for counseling regarding the particular off-campus courses they may require to qualify for enrollment in a given curriculum and those courses that would serve to strengthen their preparation for the graduate program of interest.

Each service identifies military billets that require specific graduate level education for successful performance. More than 6,000 subspecialty coded billets are presently identified in the Navy. Quotas for officer inputs to graduate education programs are generated annually to ensure that a sufficient number of officers with subspecialty codes will be available to meet current and projected billet requirements. Sponsors such as the Naval Sea Systems Command and Naval Air Systems Command identify the skill requirements for subspecialty coded billets, and the Naval Postgraduate School administers curricular programs to meet the promulgated skill requirements. Subspecialty codes, titles, and curriculum numbers for the Navy are listed in the table below:

Curriculum Number	*Curriculum Title*	*Admission APC*	*Subspecialty Code*	*Degree*
360	Operations Analysis	324	XX42P	M.S. Operations Research
365	Command, Control & Communication (C^3)	325	XX45P	M.S. C^3
366	Space Systems Operations	324	XX76P	M.S. System Tech.
367	Computer Systems Management	335	XX95P	M.S. Information Systems
368	Computer Science	325	XX91P	M.S. Computer Science
372	Meteorology	323	XX48D	Ph.D. Only
373	Air-Ocean Science	323	XX47P	M.S. Meteorology & Oceanography
374	Operational Oceanography	323	XX49P	M.S. Meteorology & Oceanography
440	Oceanography	323	XX49D	Ph.D. Only
525	Antisubmarine Warfare Systems Technology	323	XX44P	M.S. Systems Technology
530	Weapons Systems Engineering	323	XX61P	M.S. Engineering Sci.
531	Weapons System Science (Physics)	323	XX63P	M.S. Physics
532	Nuclear Physics (Weapons & Effects)	323	XX67P	M.S. Physics
535	Underwater Acoustics	323	XX56P	M.S. Engineering Acoustics
570	Naval/Mechanical Engineering	323	XX54P	M.S. Mechanical Eng. or or Engineer Sci.
590	Electronic Systems Engineering	323	XX55P	M.S. Electrical Eng.
591	Space Systems Engineering	323	XX77P	M.S. Electrical Eng.
595	Electronic Warfare Systems Tech.	325	XX46P	M.S. Systems Tech.
600	Communication Engineering	323	XX81P	M.S. Electrical Eng.
610	Aeronautical Engineering	323	XX71P	M.S. Aeronautical Eng.
611	Aeronautical Engineering-Avionics	323	XX72P	M.S. Aeronautical Eng.
620	Telecommunications Systems Mgt.	335	XX82P	M.S. Telecommunications Systems Mgt.
681	National Security Affairs (Middle East, Africa, South Asia)	365	XX21P	M.A. National Security Affairs
682	National Security Affairs (Far East, South East Asia, Pacific)	365	XX22P	M.A. National Security Affairs
683	National Security Affairs (Europe, USSR)	365	XX24P	M.A. National Security Affairs
684	National Security Affairs (International Organizations & Negotiations)	365	XX25P	M.A. National Security Affairs
685	National Security Affairs (Western Hemisphere)	365	XX23P	M.A. National Security Affairs
686	National Security Affairs (Strategic Planning-General)	345	XX26P	M.A. National Security Affairs
687	National Security Affairs (Strategic Planning-Nuclear)	345	XX27P	M.A. National Security Affairs
813	Material Movement	345	1304P	M.S. Management
814	Transportation Management	345	XX35P	M.S. Management
815	Acquisition & Contract Management	345	1306P	M.S. Management
819	Systems Inventory Management	345	1302P	M.S. Management
825	Intelligence	334	XX17P	M.A. National Security Affairs
827	Material Logistics Support Management	345	XX32P	M.S. Management
837	Financial Management	345	XX31P	M.S. Management
847	Manpower, Personnel & Training Analysis	345	XX33P	M.S. Management
857	Organizational Development	345	XX38P	M.S. Management

CURRICULAR OFFICES

Title	*Organizational Code*	*AUTOVON*
Administrative Science	36	878-2536
Aeronautical Engineering	31	878-2491
Air-Ocean Science	35	878-2044
Antisubmarine Warfare	331	878-2116
Command, Control, and Communications (C3)	39	878-2772
Computer Technology	37	878-2174
Electronics and Communications	32	878-2056
National Security and Intelligence	38	878-2228
Naval Engineering	34	878-2033
Operations Analysis	30	878-2786
Weapons Engineering	33	878-2116

CURRICULA

Curriculum	*Curriculum Number*	*Normal Length (Months)*	*Normal Convening Dates*	*Cognizant Curricular Office Code*
Administrative Science				
(Material Movement)	813	18	July	36
(Transportation Management)	814	18	July	36
(Acquisition & Contract Management)	815	12-18	January, July	36
(Allied Officers, DOD Civilians, USA, USMC and USCG)	817	12-18	January, July	36
(Systems Inventory Management)	819	18	July	36
(Material Logistics Support Management)	827	18	July	36
(Financial Management)	837	18	January, July	36
(Manpower/Personnel Training Analysis)	847	18	January, July	36
(Organization Development)	857	18	January, July	36
Aeronautical Engineering	610	24	Any Quarter	31
Aeronautical Engineering Avionics	611	24	Any Quarter	31
Air-Ocean Science	373	24	Any Quarter	35
Antisubmarine Warfare	525	24	April, October	331
Command, Control, and Communications (C3)	365	18	October	39
Communications Engineering	600	21-27	Any Quarter	32
Computer Science	368	21	April, October	37
Computer Systems	367	18	April, October	37

CURRICULA

Electronic Warfare Systems Technology	595	24	October	32
Electronic Systems Engineering	590	21-27	Any Quarter	32
Engineering Science	460	3-6	Any Quarter	Any
Intelligence	825	18	February, August	38
Meteorology	372	24-36	Any Quarter	35
National Security Affairs				
(Middle East, Africa, South Asia)	681	12-24	January, July	38
(Far East, Southeast Asia, Pacific)	682	12-24	January, July	38
(Europe, USSR)	683	12-24	January, July	38
(International Organizations and Negotiations)	684	18	July	38
(Western Hemisphere)	685	12-24	January, July	38
(Strategic Planning - General)	686	18	January, July	38
(Strategic Planning - Nuclear)	687	18	January, July	38
Naval Engineering	570	24-27	Any Quarter	34
Nuclear Physics (Weapons & Effects)	532	24-27	April, October	33
Oceanography	440	24-36	Any Quarter	35
Operational Oceanography	374	24	Any Quarter	35
Operations Analysis	360	24	April, October	30
Space Systems Engineering	591	27	Any Quarter	32
Space Systems Operations	366	24	October	32
Technical Transition Program	465	3-6	Any Quarter	Any
Telecommunications Systems Management	620	18	October	32
Underwater Acoustics	535	24-27	April, October	33
Weapons Systems Engineering	530	24-27	April, October	33
Weapons Systems Science	531	24-27	April, October	33

ADMINISTRATIVE SCIENCE PROGRAMS CURRICULA NUMBERS 813, 814, 815, 817, 819, 827, 837, 847, 857

Frank Boyd Keller, Commander, U.S. Navy; Curricular Officer, B.S., U.S. Naval Academy, 1966; M.S.,Naval Postgraduate School, 1972.

David Vincent Lamm, Commander, U.S. Navy, Instructor in Administrative Sciences; Academic Associate (Acquisition & Contract Mgmt-815) B.A., Univ. of Minnesota, 1964; M.B.A., George Washington Univ., 1972; D.B.A., 1976.

Dan Calvin Boger, Assistant Professor of Economics; Academic Associate (Material Movement-813, Transportation Management-814, and USMC-817); B.S., Univ. of Rochester, 1968; M.S., Naval Postgraduate School, 1969; M.A., Univ. of California at Berkeley, 1977; Ph.D., 1979.

David Richard Whipple, Jr., Professor of Economics and Systems Analysis; Academic Associate (Manpower/Personnel Training Analysis-847); B.A., Univ. of St. Thomas, 1964; M.A., St. Mary's Univ., 1966; Ph.D., Univ. of Kansas, 1971.

Carson Kan Eoyang, Associate Professor of Management; Academic Associate (Organizational Development-857); B.A., Massachusetts Institute of Technology, 1966; M.B.A., Harvard Univ., 1968; Ph.D., Stanford Univ., 1976.

Roger Dennis Evered, Associate Professor of Administrative Sciences; Academic Associate (Administrative Sciences, International-817); B.S., Univ. of London, 1953; M.S., Univ. of California at Los Angeles, 1972; Ph.D., 1973.

Joseph Girard San Miguel, Professor of Accounting; Academic Associate (Financial Management-837); B.B.A., Univ. of Texas, 1967; M.B.A., North Texas State Univ., 1968; Ph.D., Univ. of Texas, 1972; C.P.A., Texas, 1969.

Kenneth James Euske, Associate Professor of Accounting; Academic Associate (Administrative Sciences, USCG, NOAA-817); A.B., Gonzaga Univ., 1967; M.B.A., Dartmouth College, 1969; D.B.A., Arizona State Univ., 1978.

George William Thomas, Associate Professor of Economics; Academic Associate (Administrative Sciences, Army-817); B.S., Southern Illinois Univ., 1967; M.S., Purdue Univ., 1969; Ph.D., 1971.

Alan Wayne McMasters, Associate Professor of Operations Research & Administrative Sciences; Academic Associate (Systems Inventory Management-819 and Material Logistics Support-827); B.S., Univ. of California at Berkeley, 1957; M.S., 1962; Ph.D., 1966.

ADMINISTRATIVE SCIENCE CURRICULA

CURRICULUM 813 — Material Movement
CURRICULUM 814 — Transportation Management
CURRICULUM 815 — Acquisition and Contract Management
CURRICULUM 817
- Allied Officer — Various Management Options
- DOD Civilian — Various management Options
- U.S. Army — Operations Research Systems Analysis (Business)
- U.S. Marine Corps — Defense Systems Analysis
- U.S. Coast Guard — Management Science

CURRICULUM 819 — Systems Inventory Management
CURRICULUM 827 — Material Logistics Support
CURRICULUM 837 — Financial Management
CURRICULUM 847 — Manpower, Personnel and Training Analysis
CURRICULUM 857 — Organization Development

OBJECTIVES — These programs are designed to:

— provide the officer with the specific functional skills required to effectively manage in a subspecialty area.

— provide the officer with a Navy/Defense Systems oriented graduate management education.

— enable the officer to evaluate the written research, study, and analysis product of others throughout his career.

— provide the officer with fundamental interdisciplinary techniques of quantitative problem-solving methods, behavioral and management science, economic analysis, and financial management.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree with above average grades is required. Completion of at least two semesters of college mathematics at the level of college algebra or trigonometry is considered to be the minimum mathematical preparation.

DESCRIPTION — These curricula are interdisciplinary programs which integrate mathematics, accounting, economics, behavioral science, management theory, operations/systems analysis, and a subspecialty concentration area into an understanding of the process by which the defense mission is accomplished. Subspecialty concentration areas are specified by ordering officers into a specific curriculum.

Officers successfully completing the program will be awarded the degree of Master of Science in Management. In addition, Naval officers who complete

one of the approved programs are awarded an appropriate subspecialty code (p-code).

Officers from the U.S. Services as well as allied officers start the curriculum with widely varied academic backgrounds. Each student's prior academic work and related military experience is evaluated for courses previously completed and applicable to the student's curriculum so that academic credits may be transferred. Validation or credit by examination is encouraged where knowledge of the material has been acquired by experience or service courses. A course load of 16 credit hours per quarter will be programmed.

FUNDAMENTALS PROGRAM

This portion of the curriculum is generally preparatory in nature and portions of it may be validated by the officer with appropriate experience or academic background. The courses contained in the Fundamentals Program are considered prerequisites to the four quarters of graduate work. Officers can enhance their selectability for Administrative Science curricula by completing prerequisite courses, or their equivalents, through off duty education, including courses available through the NPS Office of Continuing Education.

The Fundamentals Program offers the following areas of study:

—Mathematics for management and probability
—Micro and macro economics
—Financial and managerial accounting
—Organizational systems
—Introduction to computers and programming
—Managerial Communication Skills

GRADUATE PROGRAM

The general Graduate portion of each program includes courses in the following areas:

Statistics
Operations research for management
Public policy processes
Policy analysis
Management information systems
Management policy

Specific courses pertaining to the various curricula include the following:

Material Movement (813)

Curriculum Courses
Material logistics
Operational Auditing in the Public Sector
Transportation management
Transportation policy

Electives
Production management
Introduction to systems acquisition and project management
Inventory I
Procurement and contract administration

Transportation Management (814)

Curriculum Courses
Material logistics
Transportation management
Transportation policy
Structure, conduct and performances of the defense industries
Automated data processing equipment acquisition

Curriculum Options (select one)
Corporate financial management
Production management
Logistics engineering

Acquisition and Contract Management (815)

Curriculum Courses
Principles of acquisition and contracting
Contract pricing and negotiations
Contract administration
Contracting for major systems
Acquisition & contract policy
Internal control and auditing

Material logistics
Electives
Production management
Corporate financial management
Industrial marketing
Seminar in acquisition and contract management

Defense Systems Analysis (817-USMC)

Curriculum Courses
Financial management in the Armed Forces
Cost estimation
Systems acquisition and project management
Curriculum Options
Analytical techniques for financial control
Contracts management and administration
Logistics engineering
Manpower and personnel models
Manpower economics I and II
Material logistics
Operational auditing in the public sector

Management Science (817-USCG)

Curriculum Courses
Financial management control systems
Personnel management processes I and II
Curriculum Options
(select courses from a minimum of 3 of the 4 groups)
GROUP 1
Decision analysis
Search theory and detection
Data analysis
System simulation
GROUP 2
Manpower requirements determination
Planning and control
Leadership and group behavior
Other manpower personnel management courses
GROUP 3
Introduction to systems acquisition and project management
Manpower economics I and II
Cost accounting
Theory of systems
Public expenditure policy and analysis
GROUP 4
Contract management and administration
Material logistics
Internal control and financial auditing
Corporate financial management
Acquisition and contracting policy
Auditing in the public sector

Management Science (817-USA)

*Required Courses**
Matrix algebra
Calculus
**These replace some of the standard Administrative Sciences fundamentals.*
Curriculum Courses
Introduction to army operations research
Linear programming
Probability and statistics
Curriculum Options
(must select at least three)
Combat models I and II
Computer simulation/systems simulation
Cost estimation
Decision and data analysis
Human factors in systems design I and II
Inventory I
Network flows and graphs
Nonlinear and dynamic programming
Stochastic models I and II

General Management for Allied Officers (817)

This curriculum offers officers from allied nations the opportunity and flexibility to design a graduate program in management which will best meet the special needs of the allied country and the unique capabilities of the individual officer. As with all administrative science department curricula, this pro-

gram requires completion of the fundamentals program, all required core graduate courses and submission of an acceptable thesis. However, unlike other curricula, this program allows students, with the guidance of a faculty academic associate, to select any mix of graduate management courses which satisfy credit hour requirements for graduation. Students may design very specialized programs, through selecting all elective courses within a single discipline or they may design a very broad general management program cutting across the numerous management disciplines. Allied officer students in this curriculum are encouraged to conduct their thesis research in an area of relevance and direct application to their home nations and sponsoring organizations.

Executive Development Program DOD Civilian (817)

This program prepares future civilian leaders of the Department of the Navy to assume positions of increased managerial responsibility. Individual programs are tailored to develop well-qualified managers and to satisfy credit hour requirements for graduation. Students are encouraged to conduct their thesis research in an area of relevance which has direct application to their sponsoring organization.

Systems Inventory Management (819)

Curriculum Courses
- Material logistics
- Inventory I
- Seminar in supply systems
- Operational auditing in the public sector

Recommended Electives
- Contract management and administration
- Introduction to systems acquisition and project management
- Logistics engineering
- Materials handling systems design
- Production management
- Transportation management

Material Logistics Support (827)

Curriculum Courses
- Material logistics or inventory management
- Logistics Engineering
- Production management

Curriculum Options
- Contracts management and administration
- Introduction to systems acquisition and project management
- Transportation management
- Materials handling systems design
- Inventory I
- Reliability, maintainability
- Operational auditing in the public sector

Financial Management (837)

Curriculum Courses
- Financial management in the Armed Forces
- Accounting theory and standards for financial reporting
- Analytical techniques for control and planning
- Corporate financial management
- Cost accounting
- Cost estimation
- Financial management control systems
- Internal control and financial auditing
- Operational auditing in the public sector
- Planning and control: measurement and evaluation
- Public expenditure, policy, analysis

All students must take 5 curriculum courses. Supply Corps and Medial Service Corps Officers may substitute one Corps related course for one curriculum course. USMC, USCG, and USN Supply Corps officers will have several predesignated curriculum courses.

Manpower, Personnel and Training Analysis (847)

Curriculum Courses
- Introduction to MPT analysis

Multivariate data analysis
Personal testing and selection
Job analysis and personal training
Manpower economics I and II
Manpower/personnel policy analysis
Manpower and personnel models
Manpower requirements determination

Organization Development (857)

Curriculum Courses
Organization development I, II, and III
Research methods
Education and training
Organization theory
O. D. field work

Recommended Electives
Planning and control
Leadership and group behavior
Military sociology
Analysis of bureaucracy
Managing planned change in complex organizations

THESIS RESEARCH

Twelve quarter hours are allocated thesis research over the last two quarters of the Graduate Program. The thesis subject will be appropriate to the subspecialty area being prepared for.

AERONAUTICAL ENGINEERING PROGRAMS CURRICULA NUMBERS 610 AND 611

William Morris Siegel, Captain, U.S. Navy; Curricular Officer; B.S., U.S. Naval Academy, 1965; Air Force TPS, 1970; M.S. in Aeronautical Engineering, Naval Postgraduate School, 1978.

Robert Diefendorf Zucker, Associate Professor of Aeronautics; Academic Associate; B.S. in M.E., Massachusetts Institute of Technology, 1946; M.M.E., Univ. of Louisville, 1958; Ph.D., Univ. of Arizona, 1966.

OBJECTIVE — To provide advanced professional knowledge in the field of Aeronautical Engineering.

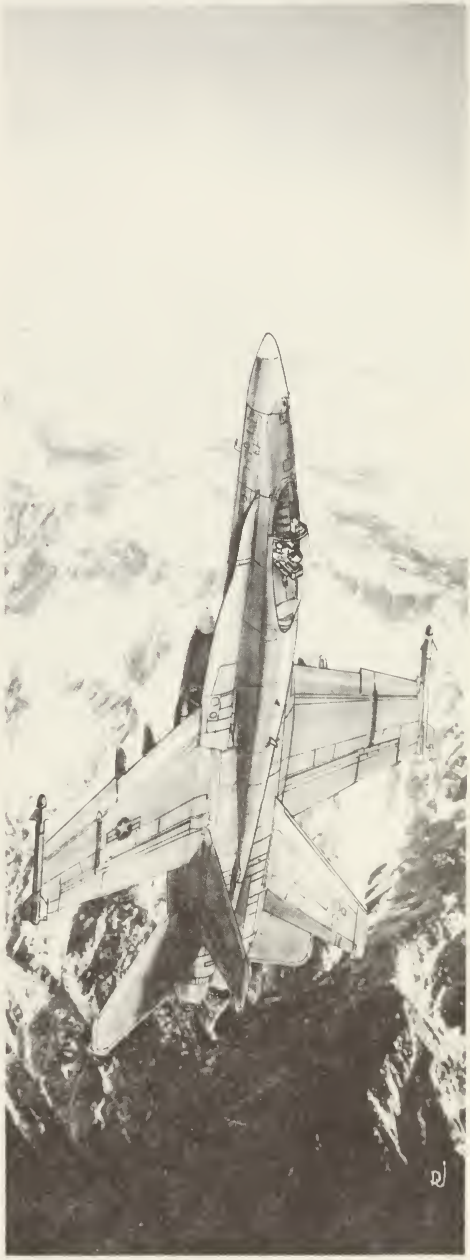
ENTRANCE REQUIREMENTS — The following are required for direct entry:

1. A baccalaureate degree or its equivalent, with an above average QPR, preferably in engineering or the physical sciences.
2. Mathematics through differential and integral calculus, with above average grades.
3. Completion of a calculus based physics sequence with above average grades.

The Engineering Science Program (Curriculum 460) is available for candidates who do not meet all the admission requirements for direct entry.

WHO CAN ATTEND — Naval aviation officers, officers of other U.S. services, and civilian employees of the U.S. federal government. Allied officers may also enroll, subject to the exclusion of particular classified courses.

DEGREE EARNED — Master of Science in Aeronautical Engineering is included as part of the program. (Advanced programs are available through the Doctorate for a few selected students.)



DURATION OF PROGRAM — Up to two years, for direct entry students, depending on their background and ability.

ENTRANCE DATES — Students qualified for "direct entry" should start an Aero program in October or April. Those requiring the Engineering Science Program should enter (a) in October or April if two quarters of Curriculum 460 are required, or (b) in January or July if one quarter of 460 is required. Contact the Aeronautical Engineering Programs Office concerning questions on your eligibility.

DESCRIPTION — The Aeronautical Engineering Programs are designed to meet the specific needs of the Navy's Operational Technical Managerial System (OTMS) for technical managers with a broad-based graduate education in Aeronautical Engineering. The opportunity for aviation officers to enroll in one of the Aeronautical Engineering Programs is dependent on a number of factors, including personal motivation and preference, professional performance, academic background, needs of the Service, and officer availability. While an undergraduate degree in engineering is naturally preferred, special preparatory programs can accommodate officers with widely varying academic backgrounds.

All Navy graduate programs exist solely to support the validated OTMS billet requirements. For each program there is a Navy consultant charged with the responsibility of identifying the educational skills to be covered by that program. For the Aeronautical Engineering Programs, the primary consultant is the Commander, Naval Air Systems Command (NAVAIR), and the subspecialty code assigned to graduates is either XX71P (for 610 graduates) or XX72P (for 611 graduates). As with other programs at the Naval Postgraduate School, the consultant-identified educational skill requirements for the Aeronautical Engineering Programs exceed the traditional requirements for a Master's degree. Therefore, while qualifying for a subspecialty code in aeronautical engineering, all "Aero" students also satisfy the academic requirements for the degree Master of Science in Aeronautical Engineering.

A new program which combines portions of the 610 curriculum at NPS Monterey with the complete U.S. Naval Test Pilot School NAS Patuxent River Md. syllabus is currently available to selected officers with strong undergraduate engineering backgrounds. Completion of this program results in the attainment of a Masters degree in Aeronautical Engineering, a Test Pilot Qualification, and the assignment of the subspecialty codes XX71P and XX73G. Application for this special program can be made in accordance with NMPC instruction 1331.1A (CH-1) of 8 August 83.

Information concerning the Aero Programs is available from the Aeronautical Engineering Programs Officer, NPS Monterey, CA 93943; AV 878-2491, Comm 408 646-2491.

PREPARATORY PHASE

Preparation for graduate study is tailored to each officer's background and is programmed for a minimum time consistent with his capability. Each student's academic transcript is evaluated for possible validation of courses in areas where a sufficiently strong record of achievement is evident. Validation or credit by examination is also possible.

Some of the subject matter in the preparatory program is available for off-campus study through the Continuing Education Office. All such Aero material is structured in "mini-courses" of one credit hour to encourage rapid completion. Each officer is urged to complete as much of this material as possible before arriving on campus.

The following material represents the minimum coverage required for entry into the graduate phase:

Linear algebra and vector analysis
Calculus and differential equations

Fluid-thermo-gasdynamics
Flight structures and dynamics
Aerodynamics-performance-stability
Circuit and system analysis
Computer programming
Material science
Aeronautical laboratories

GRADUATE CORE

After the preparatory program, students enter into a common Graduate Core designed to provide advanced knowledge in each of the four principal areas of aeronautics:

Aircraft and missile propulsion
Current aerodynamic analysis
Flight vehicle structural analysis
Stability and control of aerospace systems

In addition to the above, the Graduate Core includes extensive study of computer methods.

ADVANCED GRADUATE PHASE

All students receive in-depth graduate coverage through elective courses in the following areas:

FLIGHT DYNAMICS — Covers the stability and control parameters, including optimal control, fly by wire, aeroelastic effects, flight evaluation techniques, for fixed and rotary wing vehicles.

FLIGHT PROPULSION — Covers the analysis of propulsion devices for aircraft and missiles along with current methods in the design of turbomachines.

GASDYNAMICS — Covers internal and external flows in the subsonic, transonic, supersonic and hypersonic regimes, including plasma flows and laser technology.

FLIGHT STRUCTURES — Covers the behavior of structural components under static and dynamic loads, including current design methodology and use of advanced fabrication techniques.

An important feature of all Aero programs is a comprehensive course in aircraft or helicopter design which comes near the end of the program.

Highlighting the final phase of Curriculum 611, Aeronautical Engineering-Avionics, are sequences in the following areas:

Guidance and control
Radar systems
Electronic warfare

Overall, approximately 80% of the course work in Curriculum 610 is common to Curriculum 611, and the degree awarded in both is the Master of Science in Aeronautical Engineering.

Each student conducts research and prepares a thesis on a topic of his choice in areas such as: manned and unmanned flight vehicles, automatic landing systems, control of flight vehicles from hovering flight to hypersonic reentry, aircraft survivability and vulnerability, blast and shock effects, flight vehicle computer applications, electro-optics, laser technology, rocket propulsion, turbomachinery design, or composite structures.

Extensive laboratory and computer facilities are available to supplement instructional and thesis research programs. In addition to the technical courses that form the structure of the graduate program and satisfy degree requirements, each student takes courses which are particularly relevant to Navy needs and professional development.

AIR-OCEAN SCIENCES PROGRAMS CURRICULA NUMBERS 373, 374, 372, 440, 441

Robert Francis Barry, Commander U.S. Navy; Curricular Officer; B.A., Iona College, 1963; M.S. in Oceanography, Naval Postgraduate School, 1972.

Joseph John von Schwind, Associate Professor of Oceanography and Geodetic Sciences; Academic Associate (Oceanography); B.S., Univ. of Wisconsin, 1952; M.S., Univ. of Utah, 1960; Ph.D., Texas A&M Univ., 1968.

Robert Lee Haney, Professor of Meteorology; Academic Associate (Meteorology); A.B., George Washington Univ., 1964; Ph.D., Univ. of California at Los Angeles, 1971.

AIR-OCEAN SCIENCES CURRICULA

373 — Air-Ocean Science
374 — Operational Oceanography
372 — Meteorology
440 — Oceanography
441 — Hydrographic Sciences

Additional information is available from the Air-Ocean Sciences Programs Curricular Officer (Code 35), NPS, Monterey, CA 93943; AV 878-2044, COMM 408-646-2044.

Primary Consultant for all Air-Ocean Sciences Curricula is:

Chief of Naval Operations (OP-952)
(Oceanographer of the Navy)
Navy Department
Washington, DC 20350
AV 294-1610; COMM 202-653-1610

AIR-OCEAN SCIENCE CURRICULUM NUMBER 373

OBJECTIVE — To provide qualified personnel with a thorough understanding of the air-sea environment and to develop the technical expertise to provide and utilize meteorological and oceanographic data and knowledge in support of all aspects of military operations.

This education enhances performance in all duties throughout a career including operational billets, technical management assignments and policy making positions. Students will develop graduate level technical ability based on general engineering and scientific principles, build a new appreciation for continuing education, acquire diverse professional knowledge, develop analytical ability for practical problem solving, broaden their capacity for original thought and discover a new personal confidence that leads to productive achievement throughout their careers.

ENTRANCE REQUIREMENTS

A baccalaureate degree in the physical sciences, mathematics or engineering is required. Completion of mathematics through differential and integral calculus and one year of college physics and one year of college chemistry are required. For USN officers, Academic Profile Code (APC) 323 is required for direct entry. The Engineering Science Program (Curriculum 460) and the Technical Transition Program (Curriculum 465) are available for candidates who do not meet all admission requirements for direct entry. OPNAVNOTE 1520 (Current series) addressing USN graduate education provides additional details.

WHO CAN ATTEND

This curriculum is designed for USN officers of the restricted line (Special Duty Oceanography). Additionally, USN officer students in the Operational Oceanography Curriculum may, upon change of designator, transfer into the Air-Ocean Science Curriculum. Officers of other uniformed services, and civilian employees of the U.S. federal government are also eligible.

DEGREE

Successful completion of the program leads to the award of the degree Master of Science in Meteorology and Oceanography.

SUBSPECIALTY CODE

USN officers who successfully complete this curriculum will be awarded the XX47P subspecialty billet code.

ENTRANCE DATES AND DURATION

Matriculation may occur any quarter. Duration depends upon the qualifications of the individual student and the curriculum objectives of the student's sponsoring agency. A typical program for students with a baccaluareate degree in either meteorology or oceanography is eight quarters. However, students may have this period shortened by validation of courses previously taken, transfer of credits and by completing, prior to enrollment, courses offered by the NPS Office of Continuing Education. For students meeting direct entry requirements, a calculus/physics refresher convenes six weeks prior to each quarter's normal commencement and is highly recommended.

DESCRIPTION — The Air-Ocean Science Curriculum is interdisciplinary in nature and encompasses those areas of meteorology, oceanography and Mapping, Charting and Geodesy (MC&G) which are directly related to environmental support of military operations. The program consists of

preparatory subjects, basic courses in dynamic and physical meteorology and oceanography and a sequence in environmental analysis and forecasting, including numerical methods by computer. The program recognizes the importance of interactions between the atmosphere and the oceans and deals with the relationships at the air/sea interface

Classroom instruction is supplemented by laboratory exercises both ashore and afloat. Guest lectures, seminars and field trips serve to round out the curriculum. Each student is required to complete a thesis. In so doing, he is introduced to research methods, develops his technical writing skills, completes a project of several quarters duration requiring initiative and originality and often solves a problem of scientific interest and practical value to the Navy. Upon completion of the program, the student is qualified to independently serve as a meteorological and oceanographic forecaster in support of military operations.

BASIC/PREREQUISITE STUDY

Preparatory courses which must be taken or be validated from prior academic work are:

- Linear algebra and vector analysis
- Differential equations
- Partial differential equations
- Computer science fundamentals/ FORTRAN programming
- Numerical analysis
- Basic probability and statistics
- Atmospheric thermodynamics
- Oceanic thermodynamics

GRADUATE CORE

BASIC DYNAMIC AND PHYSICAL METEOROLOGY AND OCEANOGRAPHY SEQUENCE:

- Physics of sound in the ocean
- Ocean influences and prediction: underwater acoustics
- Physical processes in the lower and upper atmosphere
- Air-ocean fluid dynamics
- Dynamic meteorology
- Dynamical oceanography
- Air-sea interaction
- Numerical air and ocean modeling
- Remote sensing of the atmosphere and oceans
- Atmospheric factors in electromagnetic and optical propagation

METEOROLOGICAL AND OCEANOGRAPHIC ANALYSIS AND FORECASTING SEQUENCE:

- Acoustic forecasting
- Wave and surf forecasting
- Meteorological analysis
- Forecasting weather elements
- Tropical meteorology
- Tropospheric and stratospheric analysis
- Ocean circulation analysis
- Analysis of air-ocean time series
- Synoptic/mesocale oceanography

BASIC COURSES IN MAPPING, CHARTING AND GEODESY (MC&G):

- Mapping, charting and geodesy
- Hydrographic and geodetic surveying.

Included in the program is a specialization option. Some suggested option areas include:

Meteorology Option

- Polar meteorology/oceanography
- Mesoscale meteorology
- Topics in satellite remote sensing
- Advanced air-sea interaction
- Advanced numerical weather prediction
- Advanced tropical meteorology
- Advanced geophysical fluid dynamics
- General circulation of the atmosphere and oceans
- Cloud physics
- Oceanic and atmospheric observational systems

Oceanography Option

Nearshore and wave processes
Oceanic and atmospheric observational systems
Polar meteorology/oceanography
Advanced air-sea interaction
Biogeochemical processes in the ocean
Topics in satellite remote sensing
Shallow water oceanography
Small scale oceanic processes
Elements of ocean prediction
General circulation of the atmosphere and oceans

MC&G Option

Hydrographic survey planning
Photogrammetry and remote sensing
Marine geophysics
Geometric and astronomic geodesy
Gravimetric and satellite geodesy
Tides

An integral part of the program is the six-week Geophysics Technical Readiness Laboratory (GTRL) following graduation. In GTRL officers are further involved in the application of meteorology, oceanography and MC&G to fleet operations through the use of a structured set of realistic scenario exercises.

OPERATIONAL OCEANOGRAPHY CURRICULUM NUMBER 374

OBJECTIVE — To provide students with a thorough understanding of the air-sea environment and operations analysis principles to forecast atmospheric, oceanic and acoustic conditions in support of all aspects of Naval operations including the ASW, EW and C3 problems. Primary emphasis is placed on the understanding of the impact of the environment (atmosphere, ocean and their interface) on weapons systems, sensors and platforms. The program recognizes the importance of interactions between the atmosphere and the oceans, and deals with the relationships at the air-sea interface.

This education enhances performance in all duties including operational billets, technical management assignments and policy-making positions. Students will develop graduate level technical ability based on general engineering and scientific principles, develop analytical ability for tactical problem solving, broaden their capacity for original thought and, in general, enhance their performance in all aspects of their professional careers.

ENTRANCE REQUIREMENTS

A baccalaureate degree in the physical sciences, mathematics or engineering is desirable. Completion of mathematics through differential and integral calculus, one year of college physics and one year of college chemistry are required. For USN officers, Academic Profile Code (APC) 323 is required for direct entry. The Engineering Science Program (Curriculum 460) or the Technical Transition Program (Curriculum 465) are available for candidates who do not meet all admission requirements for direct entry. OPNAVNOTE 1520 (current series) addressing USN graduate education provides additional details.

WHO CAN ATTEND

The Curriculum is open to all USN unrestricted line officer communities (surface, sub-surface, and aviation), officers of other uniformed services, and civilian employees of the U.S. federal government.

DEGREE

Successful completion of the program leads to the award of the degree Master of Science in Meteorology and Oceanography.

SUBSPECIALTY CODE

USN officers who successfully complete this curriculum will be awarded the XX49P subspecialty billet code.

ENTRANCE DATES AND DURATION

Matriculation may occur any quarter. Duration depends on the qualifications of the individual student and curriculum objectives of the student's sponsoring agency. Although a typical program is designed for eight quarters, qualified students may have this period shortened by validation of courses previously taken, transfer of credits and by completing, prior to enrollment, courses offered by the NPS Office of Continuing Education. For students meeting direct entry requirements, a calculus/physics refresher convenes six weeks prior to each quarter's normal commencement and is highly recommended.

DESCRIPTION

The interdisciplinary Operational Oceanography Curriculum provides a firm foundation in meteorology, oceanography and operations analysis principles as applied to all aspects of naval warfare. The program consists of preparatory numerical and statistical analysis subjects, basic courses in dynamical and physical meteorology and oceanography, a sequence in air-ocean analysis and forecasting, including numerical methods by computer and a sequence of Naval warfare-oriented courses.

Classroom instruction is supplemented by laboratory exercises both ashore and afloat. Guest lecturers, seminars and field trips serve to round out the curriculum. Each student is required to complete a thesis. In so doing, he is introduced to research methods, develops his technical writing skills, completes a project of several quarters duration requiring initiative and originality and often solves a problem of scientific interest and practical value to the Navy.

BASIC/PREREQUISITE STUDY

Preparatory courses which must be taken or be validated from prior academic work are:

Linear algebra and vector analysis
Differential equations
Partial differential equations
Computer science fundamentals/ FORTRAN programming
Basic probability and statistics
Atmospheric thermodynamics
Oceanic thermodynamics

GRADUATE CORE

BASIC DYNAMIC AND PHYSICAL METEOROLOGY AND OCEANOGRAPHY SEQUENCE:

Physics of sound in the ocean
Ocean influences and prediction: underwater acoustics
Air-ocean fluid dynamics
Dynamic meteorology
Dynamical oceanography
Air-sea interaction
Remote sensing of the atmosphere and oceans
Atmospheric factors in electromagnetic and optical propagation
Ocean circulation analysis

METEOROLOGICAL AND OCEANOGRAPHIC ANALYSIS AND FORECASTING SEQUENCE:

Acoustic forecasting
Wave and surf forecasting
Meteorological analysis
Forecasting weather elements
Tropospheric and stratospheric analysis
Analysis of air-ocean time series
Tropical meteorology
Synoptic/mesoscale oceanography

OPERATIONAL OCEANOGRAPHY NAVAL WARFARE SEQUENCE:

Introduction to applied probability for systems technology

- Decision and data analysis
- Weapons systems and weapons effects
- Simulation and war gaming
- Introduction to combat models and weapons effectiveness
- Search, detection and localization models

Included in the program is a specialization option. Refer to the Air-Ocean Science Curriculum (#373) for some suggested emphasis areas.

METEOROLOGY CURRICULUM NUMBER 372

OBJECTIVE — To provide qualified personnel with a sound understanding of the science of meteorology and to develop the technical expertise to provide, and utilize, meteorological and oceanographic data in support of all aspects of military operations.

This education enhances performance in all duties throughout a career including operational billets, technical management assignments and policy making positions. Personnel will develop sound graduate level technical ability based on general engineering and scientific principles, build a new appreciation for continuing education, acquire diverse professional knowledge, become aware of the many complex elements of problems, develop analytical ability for practical problem solving, broaden their capacity for original thought and discover a new personal confidence that leads to productive achievement throughout their professional careers.

ENTRANCE REQUIREMENTS

A baccalaureate degree with completion of mathematics through differential and integral calculus and a minimum of one year of college physics is required. The Engineering Science Program (Curriculum 460) is available for candidates who do not meet all admission requirements for direct entry.

WHO CAN ATTEND

The program is open to officers of other uniformed services, allied officers and qualified civilian employees of the U.S. federal government. USN officers of the unrestricted line attend the Operational Oceanography Curriculum (#374). USN restricted line officers attend the Air-Ocean Science Curriculum (#373). See preceding pages for details.

DEGREE

Successful completion of the program leads to the award of the degree Master of Science in Meteorology.

ENTRANCE DATES AND DURATION

Matriculation may occur any quarter. Duration depends on the qualifications of the individual student and curriculum objectives of the student's sponsoring agency. Although a typical program is designed for seven academic quarters, students qualified may have this period shortened by validation of courses previously taken, transfer of credits and by completing, prior to enrollment, courses offered by the NPS Office of Continuing Education. For students meeting direct entry requirements, a calculus/physics refresher convenes six weeks prior to each quarter's normal commencement and is highly recommended.

DESCRIPTION — The Meteorology Curriculum is interdisciplinary in nature and encompasses those areas of meteorology which are directly related to environmental support of operations. The program consists of preparatory subjects and course sequences in synoptic, physical and dynamic meteorology, with emphasis on numerical prediction. The program recognizes the interaction of the atmosphere and the ocean and deals with the important relationships at the air/sea interface.

Classroom instruction is supplemented by laboratory exercises, computer solutions to problems and guest lecturers and seminars. Upon completion of the program, the student is qualified to serve independently as a meteorological forecaster. By completing a required thesis, he is introduced to the problems associated with independent research.

BASIC/PREREQUISITE STUDY

Preparatory courses which must be taken or be validated from prior academic work are:

Linear algebra and vector analysis
Differential equations
Partial differential equations
Numerical analysis
Computer science fundamentals/ FORTRAN Programming
Basic probability and statistics
Atmospheric thermodynamics

GRADUATE CORE

BASIC DYNAMIC AND PHYSICAL METEOROLOGY SEQUENCE:

Physical processes in the lower and upper atmosphere
Air-ocean fluid dynamics
Dynamic meteorology
Air-sea interaction
Numerical air and ocean modeling
Atmospheric factors in electromagnetic and optical propagation
Remote sensing of the atmosphere and oceans

METEOROLOGICAL ANALYSIS AND FORECASTING SEQUENCE:

Meteorological analysis
Tropospheric and stratospheric meteorology
Tropical meteorology
Forecasting weather elements
Mesoscale meteorology
Analysis of air-ocean time series

METEOROLOGICAL ELECTIVES:

Advanced geophysical fluid dynamics
Advanced tropical meteorology
Advanced numerical weather prediction
General circulation of the atmosphere/oceans
Polar meteorology/oceanography
Topics in satellite remote sensing
Advanced air-sea interaction
Oceanic and atmospheric observational systems
Cloud physics
Atmospheric turbulence

Ample time is provided for students to complete research for a thesis in the area of their primary interest. Specialization option tracks may be developed using courses offered by other NPS academic department.

Ph.D. PROGRAMS

For Ph.D Program details, refer to the Department of Meteorology Section of this catalog. USN restricted line officer Ph.D. application procedures are addressed in OPNAVINST 1520.23 (current edition).

OCEANOGRAPHY CURRICULUM NUMBER 440

OBJECTIVE — To provide students with a sound understanding of the science of oceanography and to develop the technical expertise to provide and utilize oceanographic and acoustical data in support of all aspects of military operations. Particular emphasis is placed on the understanding of oceanic effects on the solution of the undersea warfare problem.

This education enhances performance in all duties throughout a military career including operational billets, technical management assignments and policy-making positions. Students will develop sound graduate level technical ability based on general

engineering and scientific principles, build a new appreciation for continuing education, acquire diverse professional knowledge, become aware of the many complex elements of problems, develop analytical ability for practical problem solving, broaden their capacity for original thought and discover a new personal confidence that leads to productive achievement throughout their careers.

ENTRANCE REQUIREMENTS

A baccalaureate degree in the physical sciences, mathematics or engineering is required. Completion of mathematics through differential and integral calculus, one year of college physics and one year of college chemistry are required. The Engineering Science Program (Curriculum 460) is available for candidates who do not meet all admission requirements for direct entry.

WHO CAN ATTEND

The program is open to officers of other uniformed services, allied officers and qualified civilian employees of the U.S. federal government. USN officers of the unrestricted line attend the Operational Oceanography Curriculum (#374). USN restricted line officers attend the Air-Ocean Science Curriculum (#373). See preceding pages for details.

DEGREE

Successful completion of this program leads to the award of the degree Master of Science in Oceanography.

ENTRANCE DATES AND DURATION

Matriculation may occur any quarter. Duration depends upon the qualifications of the individual student and the curriculum objectives of the student's sponsoring agency. Although a typical program is designed for eight quarters, qualified students may have this period shortened by validation of courses previously taken, transfer of credits and by completing, prior to enrollment, courses offered by the NPS Office of Continuing Education. For students meeting direct entry requirements, a calculus/physics refresher convenes six weeks prior to each quarter's normal commencement and is highly recommend.

DESCRIPTION — The Oceanography Curriculum 440 focuses on physical oceanography, and relates it to oceanographic support of military operations.

Classroom instruction is supplemented by laboratory exercises both ashore and afloat. Guest lectures and seminars serve to round out the curriculum. Each student is required to complete a satisfactory thesis. In so doing the officer is introduced to the concept of applying theoretical knowledge toward a practical application.

BASIC/PREREQUISITE STUDY

Preparatory courses which must be taken or be validated from prior academic work are:

Linear algebra and vector analysis
Differential equations
Partial differential equations
Computer science fundamentals/FORTRAN programming
Numerical analysis
Basic probability and statistics
Atmospheric thermodynamics
Oceanic thermodynamics

GRADUATE CORE OCEANOGRAPHY

BASIC PHYSICAL AND DYNAMICAL OCEANOGRAPHY SEQUENCE:

Physics of sound in the ocean
Ocean influences and prediction: underwater acoustics
Air-ocean fluid dynamics

Dynamical oceanography
Numerical air and ocean modeling
Dynamic meteorology
Air-sea interaction
Advanced air-sea interaction
Remote sensing of the atmosphere and oceans

ANALYSIS AND FORECASTING SEQUENCE:

Synoptic/mesoscale oceanography
Meteorological analysis
Wave and surf forecasting
Nearshore and wave processes
Analysis of air-ocean time series
Ocean circulation analysis
Polar meteorology/oceanography
Oceanic and atmospheric observational systems
Shallow water oceanography
Tides

Specialization option tracks may be developed using courses offered by other NPS academic departments.

Ph.D. PROGRAMS

For Ph.D. Program details, refer to the Department of Oceanography section of this catalog. USN restricted line officer Ph.D. application procedures are addressed in OPNAVINST 1520.23 (current series).

HYDROGRAPHIC SCIENCES CURRICULUM NUMBER 441

OBJECTIVE — To provide students with a sound understanding of oceanography and hydrography. Hydrography (a subdiscipline of mapping, charting and geodesy (MC&G)) is the science of the measurement, description and charting of the sea floor with special reference to navigation and marine operations. This interdisciplinary program integrates the scientific principles of oceanography with the practical engineering procedures of hydrography. Students achieve the technical expertise to provide and utilize hydrographic data in support of all aspects of hydrographic operations.

This education enhances performance in duties associated with operational billets, technical management assignments and policy making positions. Students will develop graduate level technical ability based on general engineering and scientific principles, develop analytical ability for practical problem solving, broaden their capacity for original thought and acquire diverse professional knowledge. These qualities will assist in supporting productive achievement throughout their career.

ENTRANCE REQUIREMENTS

A baccalaureate degree with above average grades in mathematics and the physical sciences. Differential and integral calculus, one year of college physics and one year of college chemistry are required. The Engineering Science Program (Curriculum 460) is available for candidates who do not meet all admission requirements for direct entry.

WHO CAN ATTEND

The program is open to officers of the National Oceanic and Atmospheric Administration, Coast Guard, Corps of Engineers, allied officers and civilian employees of the U.S. federal government. USN officers of the unrestricted line attend the Operational Oceanography Curriculum (#374). USN restricted line officers attend the Air-Ocean Science Curriculum (#373). See preceding pages for details.

DEGREE

The degree Master of Science in Hydrographic Sciences is granted upon successful completion of the program.

ENTRANCE DATES AND DURATION

Matriculation may occur any quarter of the year with preferred entry in the fall. Duration depends upon the qualifications of the individual student and

the curriculum objectives of the student's sponsoring agency. A typical program consists of eight quarters. However, highly qualified students may have this period shortened by validation of courses previously taken, transfer of credits and by completing, prior to enrollment, courses offered by the NPS Office of Continuing Education. For students meeting direct entry requirements, a calculus/physics refresher convenes six weeks prior to each quarter's normal commencement and is highly recommended.

DESCRIPTION — The program consists of preparatory subjects, basic courses in numerical and statistical analysis, a dynamics sequence and a core of MC&G subjects. The curriculum recognizes the importance of precise positioning systems, error budget analysis, accuracy requirements, data collection methods and data reduction techniques as applied to the planning, conduct and evaluation of hydrographic, magnetic and gravity surveys. Graduates will be prepared to make optimum use of the ocean environment in the course of their duties and to conduct and evaluate research in oceanography and hydrography, both basic and applied.

Classroom instruction is supplemented by laboratory exercises both ashore and afloat. Guest lectures, seminars and field trips serve to round out the curriculum. Each student is required to complete a thesis. In so doing, he is introduced to research methods and develops his technical writing skills, while at the same time completing a project of several quarters duration that requires planning, initiative and originality. The student often solves a problem of scientific interest and practical value to his sponsoring agency.

BASIC/PREREQUISITE STUDY

Preparatory courses which must be taken or be validated from prior academic work are:

- Linear algebra and vector analysis
- Differential equations
- Computer science fundamentals/ FORTRAN programming
- Basic probability and statistics
- Marine meteorology
- Oceanic thermodynamics
- Partial differential equations
- Computing devices and systems
- Ocean, maritime and tort law

GRADUATE CORE

BASIC PHYSICAL AND DYNAMICAL OCEANOGRAPHY SEQUENCE:

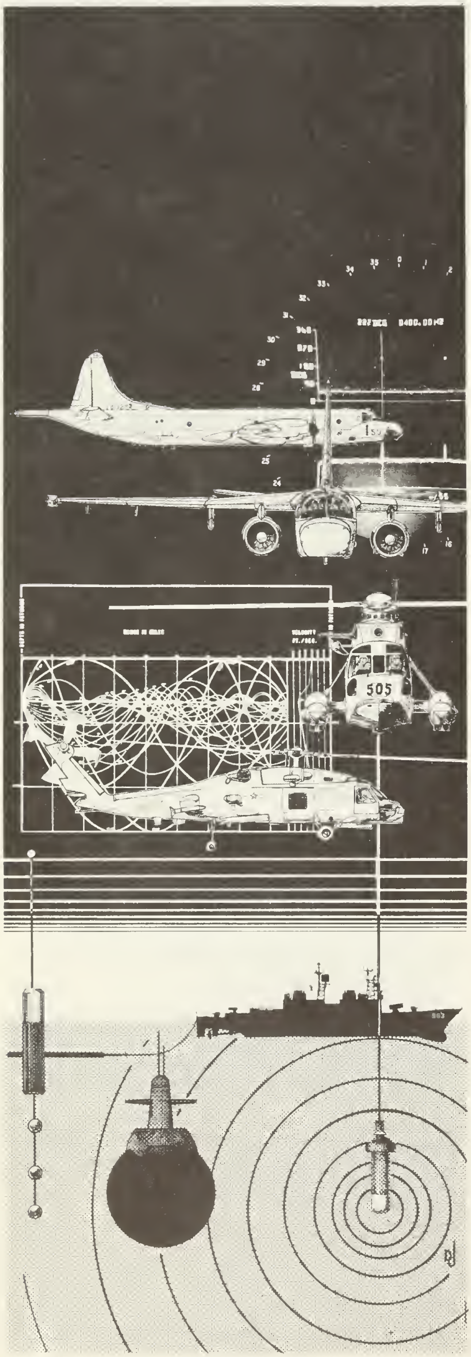
- Biogeochemical processes in the ocean
- Sound in the ocean
- Mechanics of fluids
- Nearshore and wave processes

THE MC&G SEQUENCE:

- Mapping, charting and geodesy
- Hydrographic and geodetic surveying
- Electronic surveying and navigation
- Hydrographic survey planning
- Hydrographic survey field experience
- Geodetic survey field experience
- Advanced hydrography
- Marine geophysics
- Tides
- Photogrammetry and remote sensing
- Geometric and astronomic geodesy
- Gravimetric and satellite geodesy

Specialization option tracks may be developed using courses offered by other NPS academic departments.

ANTISUBMARINE WARFARE PROGRAM
CURRICULUM 525



John Harvey Long, Commander, U.S. Navy; Curricular Officer; B.S.M.E., U.S. Naval Academy, 1971; M.S., Naval Postgraduate School, 1978.

James Vincent Sanders, Academic Associate; B.S., Kent State Univ., 1954; Ph.D., Cornell University, 1961.

OBJECTIVES — This program is designed to:

— Enhance operational and command competence, afloat and ashore, of URL officers in the warfare specialties for the subcategory of ASW.

— Educate officers in the fundamentals of engineering, the environment, and in the use of analytic techniques so that they can understand the basic phenomena which affect the capability of the ASW system(s) for which they are directly responsible.

— Educate officers in the fundamentals of "ASW Systems Engineering" so that they will be able to translate operational requirements into systems effectiveness including the man-machine interface, and to view all of the components of a large system in proper perspective.

— Educate officers in the politico-military and decision-making environment involving Soviet naval activities, net threat assessment and the Washington decision process.

— Develop officers' ability to analyze and develop ASW tactics, to evaluate ASW-related experiences critically, and to state clearly the nature of problems which are associated with ASW systems and operations.

— Provide officers with project-type, practice-oriented experience so that they will develop the ability to relate fundamental concepts directly to ASW operational application.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree, or equivalent, from a program with a calculus sequence and a calculus-based

physics sequence that results in an Academic Profile Code (APC) of 323 is required for direct input. Courses in the physical sciences and engineering are desirable. An additional qualification for entry is that a selectee must have demonstrated strong professional performance in at least one ASW mission unit.

Officers not meeting the academic requirements for direct input enter the program via three or six months of the Engineering Science Curriculum or the Technical Transition Program. Refer to the information on those programs in this catalog.

Officers may improve their APC's and enhance their selectability by taking off-campus courses at civilian institutions or through the Postgraduate School Continuing Education Program. Refer to the information presented in the Academic Profile Code and Continuing Education Program sections of this catalog.

DESCRIPTION — The operational employment of diverse antisubmarine warfare sensor and weapon systems in the demanding oceanic environment involves complex man-machine interactions. The ASW Curriculum educates officers in the engineering fundamentals, physical principles and analytic concepts that govern that employment, and includes extensive breadth in the appropriate scientific and technical disciplines.

This interdisciplinary program integrates mathematics, physics, acoustics, electrical engineering, oceanography, operations analysis, human factors, computer science and meteorology. The academic content divides naturally into four major areas: Electrical Engineering with emphasis on signal processing, Underwater Acoustics with emphasis on signal propagation and detection, Operations Analysis with emphasis on tactical application and decision analysis, and Air-Ocean Sciences with emphasis on the environmental factors affecting sound in the sea. The program is structured around course sequences in each of these four areas.

The curriculum includes ten undergraduate level courses, seventeen graduate level courses, one graduate level elective, a six-week experience tour and twelve quarter hours of thesis research. The undergraduate level courses are included to account for the fact that the typical officer student has been away from the academic environment for several years and will need some preparation before engaging in graduate studies.

The experience tour, elective course and thesis research allow the ASW student the opportunity to specialize in an area of his choice. The wide variety of disciplines included in the curriculum permits a unique degree of flexibility in choosing that area of specialization.

Officer graduates of the ASW Curriculum receive the subspecialty designation XX44P and return to operational ASW billets. Although the curriculum emphasizes operational applications, graduates are prepared to perform in technical or managerial positions. As their careers progress, they typically qualify as proven subspecialists (XX44Q) and serve in critical ASW billets. Graduates are awarded the degree Master of Science in Systems Technology.

INTRODUCTORY STUDY

The following undergraduate level courses, which are described in the Academic Departments and Course Descriptions section of this catalog, are included in the core curriculum: MA1112, MA2129, MA2181, OC2120, ST1810, MA3139, OS2103, EC2721, PH2119, PH2471 and MR2413. With the approval of the Curricular Officer and Academic Associate, qualified officers may validate some of the undergraduate courses to allow time for additional electives.

These courses cover the following subjects:

Elements of linear algebra, ordinary differential equations and Laplace transforms
Vector calculus
Applied probability theory
Computer systems and

programming
Electronic systems
Survey of oceanography
Meteorology for ASW
Physics of sound in the ocean
Introduction to the sonar equations

GRADUATE STUDY

The following graduate level courses, which are described in the Academic Departments and Course Descriptions section of this catalog, complete the core curriculum: MA3139, OS3303, OS3604, EC3714, EC4716, OS3601, PH3472, OC4267, PH3366, EC4451, PH3281, PH4473, OS3402, OS4601, OS3602, NS3152 and PH3479.

These courses cover the following subjects:

Fourier analysis and partial differential equations
Decision analysis, statistics and data analysis
Computer simulation techniques
Search detection and localization models
Combat models and weapons effectiveness
Signals and noise
Signal processing systems
Sonar systems engineering
Electromagnetic wave propagation
Non-acoustic sensor systems
Fundamentals of acoustics
Underwater acoustics
Environmental factors in underwater acoustics
Environmental prediction for underwater sound propagation
Human vigilance performance
Intelligence, threat analysis
Fundamentals of underwater weapons

EXPERIENCE TOUR — During the last six weeks of the fifth quarter of the curriculum, each U.S. officer student conducts research in a selected field of interest at one or more ASW-related activities located away from the Postgraduate School. The experience tour provides a valuable opportunity to apply what has been learned in the classroom to real problems, to participate in the weapon systems research and development process and to find a thesis research topic beneficial to the student and relevant to Navy needs. The following activities are some of the sponsors of the experience tour program:

Naval Ocean Systems Center
Naval Air Development Center
Naval Underwater Systems Center
Naval Surface Weapons Center
Johns Hopkins Applied Physics Laboratory
Naval Undersea Warfare Engineering Station
Naval War College
Naval Ocean Research and Development Activity
Naval Research Laboratory
Third Fleet
Naval Air Systems Command

ELECTIVE COURSE — One elective course is included in the curriculum. The primary purpose of the course is to support thesis research in the student's area of specialization.

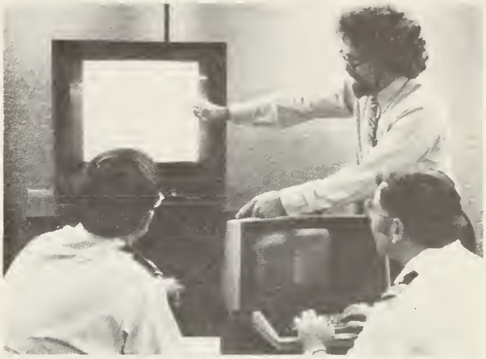
THESIS RESEARCH — Twelve quarter-hours of the last two quarters of the curriculum are devoted to an ASW-related thesis. It is a degree requirement and allows the student to apply his graduate education and experience to a challenging project that directly relates to an existing problem in the ASW community.

To complete the ASW program, active guest lecture and seminar presentations keep students abreast of new developments and "state of the art" technology. Organized field trips to laboratories and operational activities representating all ASW-related warfare specialties expose students to current applications of theory learned in the classroom. With classes composed of officers from all ASW communities, an additional and important benefit of the program is the development in each student of a better understanding of how each community approaches the ASW problem. This integrated program of classroom theory, seminars, field trips, experience tours, and thesis research creates a firm background of professional knowledge which is directly applicable to the ASW subspecialty area.

JOINT COMMAND, CONTROL AND COMMUNICATIONS (C3) PROGRAM CURRICULA NUMBERS 365, 366

John T. Malokas, Lieutenant Colonel, U.S. Air Force; Curricular Officer; B.S., Ohio University, 1966; M.S., Univ. of Southern California, 1973; M.S. in Systems Technology, Naval Postgraduate School, 1979.

Carl Russell Jones, Professor of Administrative Sciences (1965); B.S., Carnegie Institute of Technology, 1956; M.B.A., Univ. of Southern California, 1963; Ph.D., Claremont Graduate School, 1965.



JOINT COMMAND, CONTROL AND COMMUNICATIONS PROGRAM CURRICULUM NUMBER 365

OBJECTIVE — To provide officers and DOD civilian equivalents, through graduate education, with a comprehensive operational and technical understanding in the field of Command, Control and Communications systems as applied to joint and combined military operations at the national and unified command levels. The graduate should have basic knowledge of the physical principles and technologies that comprise communications systems, computers and sensors. The graduate should be able to analyze the technical and operational aspects of C3 environments and effectively interface with engineers, planners and operational personnel in the development of new C3 systems and the improvement of old C3 systems. These Officers should be able to undertake a wide range of assignments in C3 (both joint and intra-service) over the full span of a career.

QUALIFICATIONS FOR ADMISSION — The Joint C3 Curriculum is open to all U.S. Military Services and selected civilian employees of the U.S. federal government. Students are normally at the O-3 and 0-4 grade level.

Admission requires a baccalaureate degree with C+ grades, and mathematics through differential and integral calculus. A Top Secret security clearance is required with Special Intelligence (SI) clearance obtainable. Classes convene annually, in October. The program is typically six quarters in duration.

DESCRIPTION — The Joint Command, Control and Communications Curriculum is multidisciplinary in nature, consisting of course work in operations research, computer science, administrative science, electrical engineering, mathematics and national security affairs. A major goal of the curriculum is to provide the student enhanced capabilities to operate effectively in such diverse areas as military decision making, current and future C3 systems design, and joint military operations. The curriculum is tailored to the requirements of selected officers who have outstanding performance records and anticipate continued careers focused on the conduct of military operations.

TYPICAL PROGRAM

INTRODUCTORY STUDY — This portion of the program is preparatory in nature, and portions of it may be validated by a student with appropriate operations and academic experience. The introductory courses include the following:

- Probability
- Applied Mathematics
- Introduction to computer science
- Computer programming
- Introduction to signals and systems

GRADUATE STUDY — The graduate level courses of the curriculum include:

- C3 mission and organization
- Man/machine interaction
- Project management
- Software design
- National intelligence systems and products
- Decision and data analysis
- Antennas and electronic warfare
- Simulation and wargaming
- C3 policies and problems
- C3 systems evaluation
- Analytical planning methodology
- Data base systems design
- Communications systems analysis

EMPHASIS SEQUENCE—Each student takes a sequence of three additional courses from the areas of computer applications, communications and sensors or tactical analysis.

THESIS — Twelve quarter hours are allocated for thesis research in the final three quarters.

SEMINARS — Integral to the program is a schedule of C3 related seminars with key military officers and civilians knowledgeable in command, control and communications.

FIELD TRIP — An orientation tour of major C3 facilities is conducted to allow the student to become familiar with existing C3 operations and associated problems.

DEGREE — Successful completion of the program leads to award of the degree of Master of Science in Systems Technology (Command, Control and Communications).

SPACE SYSTEMS OPERATIONS CURRICULUM NUMBER 366

OBJECTIVE (SPECIFIC)—To provide officers with an appreciation for military opportunities and applications in space, a comprehensive practical as well as theoretical knowledge of the operation, tasking and employment of space surveillance, communications, navigation, and atmospheric/oceanographic/environmental sensing systems, and a knowledge of payload design and integration.

QUALIFICATIONS FOR ADMISSION—This curriculum is open only to officers of the U.S. Armed Forces and selected civilian employees of the U.S.

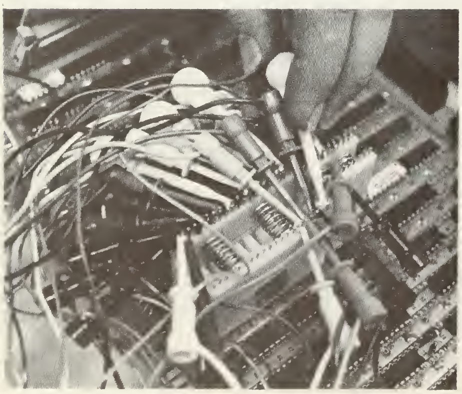
federal government. Admission to the curriculum requires a baccalaureate degree with above average grades. Completion of mathematics through differential and integral calculus is required. Students lacking this background may matriculate via the Engineering Science Program. A Top Secret security clearance is required with Special Intelligence (SI) clearance obtainable.

DESCRIPTION — The 366 curriculum is sponsored by the Director, Navy Space Systems Division. Officer graduates will be prepared by their education to develop the requirements, strategy, and doctrine for acquiring, and future military and civil space systems in force enhancement and application as well as space support and control roles. Officer graduates will have the ability to exploit existing space systems in order to apply capabilities to fleet support. The curriculum is eight quarters long, and input occurs annually in October. The graduate earns the degree Master of Science in Systems Technology.

The Space Systems Operations curriculum is interdisciplinary and comprises several tracks. Subjects covered include:

- Calculus and applied probability
- Applied mathematics
- Structured programming with FORTRAN
- Software design
- Introduction to signals and systems
- Decision and data analysis
- Simulation and wargaming
- Search theory and detection
- Analytic planning methods
- C3 organization and missions
- National intelligence systems and products
- Remote sensing
- Transmission systems
- Introduction to space science
- Spacecraft systems I and II
- Military applications of space
- Project management
- Orbitology
- Communications Systems Analysis
- Space Warfare

COMPUTER TECHNOLOGY PROGRAMS CURRICULA NUMBERS 367 AND 368



Michael John Anderson, Commander, U.S. Navy; Curricular Officer; B.S., Univ. of Oklahoma, 1965, M.S., Computer Systems Management, Naval Postgraduate School, 1974.

Norman Floyd Schneidewind, Professor of Information Science; Academic Associate (Computer Systems); B.S.E.E., Univ. of California at Berkeley, 1951; M.S.C.S., San Jose State Univ., 1983; M.B.A., Univ. of Southern Calif., 1960; M.S.O.R. (ENGR), 1970; D.B.A., 1966; C.D.P., 1976.

Uno Robert Kodres, Professor of Computer Science; Academic Associate (Computer Science); B.A., Wartburg College, 1954; M.S., Iowa State Univ., 1956; Ph.D., 1958.

COMPUTER SYSTEMS MANAGEMENT CURRICULUM NUMBER 367

OBJECTIVES — This program is designed to:

— Provide the officer with the knowledge, skills, and practical understanding to evaluate changes and advances in the management of computers in the Military Services.

— Educate the officer in the technical aspects of computers and computer systems so that, in consonance with his management skills, he can effectively manage the implementation and proper utilization of computer based systems in military operations.

— Educate the officer in the fundamentals of systems development so that he is capable of translating operational requirements into systems specifications.

— Educate the officer in the concepts of economic analysis of computers in order to optimize costs and benefits.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree or the equivalent with above average grades in mathematics is required. Completion of differential and integral calculus and a course in psychology is considered minimal preparation. Students lacking these quantitative prerequisites may be acceptable for the program providing their undergraduate records and/or other indicators of success such as: GRE (Graduate Record Examination) GMAT (Graduate Management Admission Test) formerly ATGSB (Admission Test for Graduate Schools of Business), indicate a capability for graduate level work.

DESCRIPTION — The Computer Systems curriculum is an interdisciplinary program which integrates mathematics, accounting, economics, computer science, behavioral science, and management disciplines to prepare the officer to manage large computer centers, networks and systems. Program flexibility is available to permit a student to pursue, in depth, a specialization in an area of interest to himself and his service community. Completion of the computer systems program requires six quarters (1½ years) or less depending on the student's academic background, experience and ability. Requirements for the Master of Science in Information Systems are met as an included part of the curricular program. In addition, Naval officers will be awarded the appropriate subspecialty code upon successful completion of the program.

Normal input for the Computer Systems curriculum is in October and April; however, on a case basis, students may commence their program in January or July through prior preparation and careful coordination with the Curricular Office.

INTRODUCTORY STUDY — This portion of the curriculum is generally preparatory in nature and some portions of it may be validated by the officer with appropriate experience or academic background. Undergraduate courses in the following areas are offered:

- Introduction to computer management
- Fundamentals of computer science
- Financial Management

GRADUATE STUDY — The graduate portion of the program includes core courses in the following areas:

- Probability and statistics
- Operations research
- Economic evaluation of information systems
- ADP systems acquisition
- Computing devices and systems
- Software development
- Operating systems
- System analysis and design
- Computer management
- Organization and management

In addition to the graduate core, students select one of the option areas listed below or may propose an alternate area. The graduate courses shown under each option area are representative of the content of the areas. However, the students may choose electives from many other courses which are available in each area.

Computer Center and Network Operations
- Computer center operations
- Computer communications and networks
- Survey of contemporary computer systems
- Distributed computer systems

Tactical Systems
- Digital machines
- Microcomputers
- Software engineering and management
- Distributed computer systems

Decision Support Systems
- Computer-based management information systems
- Distributed computer systems
- Information and decision systems
- Applications of database management systems

Information and Computer Systems and Networks
Telecommunication systems, industry, regulations
Computer communications and networks
Real-time information systems
Distributed computer systems

PROJECT/THESIS RESEARCH — Twelve quarter hours are allocated for research, four in each of the student's final three quarters. Emphasis is on a group project or individual thesis derived from a military application in the field of computer systems management. The topic will be appropriate to the emphasis area selected.

COMPUTER SCIENCE CURRICULUM NUMBER 368

OBJECTIVE — This program is designed to:

— Provide an officer with the knowledge and skills necessary to specify, evaluate, and manage the design of computer systems.

— Provide technical guidance in applications ranging from basic data processing to sophisticated tactical systems.

— Educate the officer in the analysis and design methodologies appropriate to an understanding of the hardware and software components of complex computer systems.

— Provide the officer with the capability to utilize the modern computer laboratory in the application of computer techniques to research current military problems.

QUALIFICATIONS FOR ADMISSION — A baccaluareate degree or the equivalent with above average grades in mathematics is required. Completion of differential and integral calculus is considered minimal preparation. Undergraduate majors in applied science or engineering are highly desirable. Students lacking these prerequisites may be acceptable for the program providing their undergraduate records and/or other indicators of success, such as the Graduate Record Examination, indicate a capability to work in quantitative subjects. Documented practical experience in the computer field will also enhance a candidate's potential for admission.

DESCRIPTION — Computer Science is concerned with the representation, storage and manipulation of data by techniques and devices applicable to a wide variety of problems. This curriculum is an interdisciplinary program combining a core of software and hardware theory and applications with studies in mathematics, probability, statistics, operations research and electronics. Completion of the Computer Science program requires seven academic quarters (1¾ years) or less, depending on the student's academic background, experience and ability. Requirements for the Master of Science are satisfied as part of the curricular programs. In addition, Naval Officers will be awarded the appropriate subspecialty code upon successful completion of the program.

Normal input for the Computer Science curriculum is in October and April; however, on an individual case basis students may commence their program in January and July through prior preparation and careful coordination with the curricular office.

INTRODUCTORY STUDY — This portion of the curriculum is generally preparatory in nature and some portions of it may be validated by the officer with appropriate experience or academic background. Undergraduate courses in the following areas are offered:

Finite mathematics
Introduction to computers and programming
Pascal, Fortran, and Cobol programming
Digital machines

GRADUATE STUDY — The graduate portion of the program includes courses in the following areas: Representative areas of study are shown:

- Applied probability and statistics
- Discrete mathematics
- Automata, formal languages and computability
- Structured programming languages
- Data structures
- Compiler design
- Operating systems
- Microcomputers
- Computer architecture
- Artificial intelligence
- Operations research
- Numerical analysis
- System design and analysis
- Management and electronics electives
- Computer communication and networks

In addition to the graduate courses, one of the following three option areas must be elected:

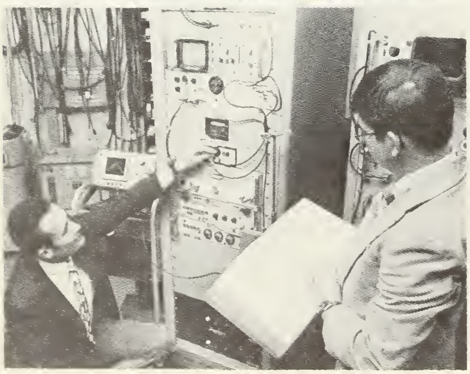
TACTICAL COMPUTER SYSTEMS
- Advanced operating systems
- Computers in combat systems
- Software engineering
- Distributed computing
- System simulation
- Electronics engineering electives

COMPUTER SOFTWARE
- Advanced programming languages
- Advanced operating systems
- Software engineering
- Data base systems
- Interactive computation systems

MILITARY DATA PROCESSING
- Computer center operations
- Data processing management
- Data base systems
- Computer communications and networks
- ADP acquisition

THESIS RESEARCH — Sixteen quarter hours are allocated for thesis research, spread over the final three quarters of the student's program. Emphasis is on military applications and research in the computer science field. The thesis subject will be appropriate to the option area selected.

ELECTRONICS AND COMMUNICATIONS PROGRAMS CURRICULA NUMBERS 590, 591, 595, 600, 620/620CG



Andrew Peter Sosnicky, Commander, U.S. Navy; Curricular Officer; B.S., U.S. Naval Academy, 1966; M.S. in Telecommunications Systems Management, Naval Postgraduate School, 1976; M.S. in Administration, George Washington Univ., 1978.

Robert Denney Strum, Professor of Electrical and Computer Engineering; /Academic Associate (Electronic Systems Engr.-590, Communications Engr.-600, Space Systems Engr.-591); B.S., Rose Polytechnic Institute, 1946; M.S., Univ. of Santa Clara, 1964.

Carl Russell Jones, Professor of Administrative Sciences; Academic Associate (Telecommunications Sysstems Management-620); B.S., Carnegie Institute of Technology, 1956; M.B.A., Univ. of Southern California, 1963; Ph.D., Claremont Graduate School, 1965.

Alfred William Madison Cooper, Professor of Physics; Academic Associate (Electronic Warfare Systems Technology-595); B.A., Univ. of Dublin, 1955; M.A., 1959; Ph.D., Queen's Univ. of Belfast, 1961.

The Electronics and Communications Programs include the following curricula:

590 Electronic Systems Engineering
591 Space Systems Engineering
595 Electronic Warfare Systems Technology
600 Communications Engineering
620 Telecommunications Systems Management

OBJECTIVES: These curricula are designed to provide graduates with technical knowledge and skills which will enable them to perform effectively

in a selected subspecialty area. Each curriculum provides the officer with a well-rounded knowledge of the scientific principles, technical practices and managerial/analytical skills pertinent to the field of study. The officer's studies also serve to produce a heightened capacity for creative thought and innovative problem solving. The curricula provide latitude for studies in associated areas outside the field of specialization to accommodate the academic background and individual interests of the officer and to help acquire diverse professional knowledge, a new appreciation for continuing education, an added awareness of the many complex elements of problems, and an enhanced personal confidence conducive to productive achievement. It is designed to enhance individual performance in all duties throughout a naval career including operational billets, technical management assignments and policy making positions, thereby preparing the officer for progressively increased responsibility including command, both ashore and afloat.

Successful completion of the Electronic Systems Engineering, Communications Engineering or Space Systems Engineering curriculum meets all requirements for the degree Master of Science in Electrical Engineering.

Graduates of the Electronic Warfare Systems Technology curriculum are awarded the degree Master of Science in Systems Engineering.

The degree Master of Science in Telecommunications Systems Management is awarded to graduates of that curriculum.

All graduates of these programs earn the appropriate subspecialty P-Code.

ELECTRONIC SYSTEMS ENGINEERING CURRICULUM NUMBER 590

OBJECTIVE (SPECIFIC) — To educate officers in current electronics technology and its application to modern naval warfare.

COMMUNICATIONS ENGINEERING CURRICULUM NUMBER 600

OBJECTIVE (SPECIFIC) — To provide officers with a comprehensive scientific and technical knowledge in the field of communications engineering as applied to Navy and Defense command, control and communication systems.

ELECTRONIC SYSTEMS ENGINEERING AND COMMUNICATIONS ENGINEERING CURRICULA NUMBERS 590 AND 600

QUALIFICATIONS FOR ADMISSION — Prior baccalaureate degree including above average grades in differential/integral calculus and general physics. Those lacking in this background may matriculate via the Engineering Science program, or may upgrade their educational opportunities by taking courses off campus through the Continuing Education Program.

Allied officers may enroll in the above curricula subject to exclusion of classified courses as determined by the Chief of Naval Operations.

DESCRIPTION — These curricula are designed to establish a broad background of basic engineering knowledge leading to selected advanced studies in electronic systems, communications, electronic warfare, ship/weapon control systems, information processing or to other pertinent areas of professional applicability. Entry may be made in any quarter.

The graduate portion of the program is normally of twelve months duration. It is preceded by an introductory core program which is designed to provide a smooth transition from previous studies and experience. For entering students who have a non-engineering background, except as stated in the qualifications above, and who have

been absent from academic studies for five or more years, the background studies may be of up to five quarters duration, leading to a complete program duration of twenty-seven months. For students with better entrance qualifications, special review courses and course validations enable them to complete the total program in twenty-one or twenty-four months.

Toward the end of their preparatory program, officers are evaluated for academic progress and potential to complete the advanced degree portion of the curriculum. Academically superior students may be selected, subject to service needs and approval, for further advanced studies leading to the degree of Electrical Engineer or Doctor of Philosophy.

INTRODUCTORY CORE

The structure of each curriculum recognizes that the typical officer student has been away from an academic environment for some time and is not usually prepared to engage in graduate studies without some preparation. The core provides a sound academic background in mathematics, computer science and technology, physics and electrical engineering. Each student's prior academic transcript will be evaluated for validation of as many of these courses as possible, or for selection of an accelerated review course to replace a longer sequence of courses. Validation permits study of greater breadth or depth in graduate studies and can reduce the time on board required to fulfill subspecialty code and degree requirements. The courses which are not validated will be programmed using a nominal course load for 16-18 credit hours per quarter.

Subjects covered in the core courses include:

- Linear algebra
- Differential equations
- Complex variables
- Numerical methods
- Applied probability
- Vector analysis
- Modern physics
- Circuit theory
- Communication theory
- Control theory
- Electronics engineering
- Linear and communications ICs
- Computer programming
- Digital logic circuits and microprocessors
- Electromagnetic wave theory

GRADUATE STUDY

The advanced studies program leading to a master's degree is individually designed to be academically sound, consistent with the needs of the service and responsive to the interests and objectives of the officer. The program consists of courses in required subject areas, elective courses in coherent and relevant option areas and thesis research. Classroom work is supplemented by an active seminar series in which military and industrial leaders provide an operationally relevant perspective on current topics of interest. The degree requirements include completion of the requirements for the degree Bachelor of Science in Electrical Engineering and completion of 40 credit hours of approved graduate study. The additional thesis research normally occupies the time equivalent for four courses, allocated during the final three quarters of the program. Any transfer of graduate credit which is applicable will allow an opportunity in an officer's program for additional electives.

The Graduate Core

To provide a well rounded graduate program, all students are required to include courses in the subject areas of digital signal processing, analysis of random signals, radiation, scattering and propagation, and microprocessor-based system design.

Options

The graduate program also requires a cohesive sequence in one of the selected areas listed below. Latitude is permitted in specific elective selections,

with the choices being approved consistent with overall professional applicability and soundness of academic requirements.

Communications systems
Guidance, navigation and control systems
Radar, electro-optic and electronic warfare systems
Computer systems

Upon successful completion of an approved curriculum, officers will be awarded an appropriate subspecialty billet code. On-going counseling is provided by the Curricular Officer/Academic Associate team for all officer students, and a close professional relationship between officer students and faculty enhances professional and career development.

ELECTRICAL ENGINEER

As determined by service needs and superior academic achievement, officers may matriculate into a program leading to the degree Electrical Engineer. This advanced graduate program requires approximately seven quarters of work beyond the introductory core. The scope of study is greatly increased over the Master of Science curriculum and a thesis of greater depth is required.

ELECTRONIC WARFARE SYSTEMS TECHNOLOGY CURRICULUM NUMBER 595

OBJECTIVE — This program is designed to:

- Provide the services with sufficient officers thoroughly knowledgeable in the technical and operational aspects of the role of Electronic Warfare (EW) as a vital, integral part of modern warfare.
- Educate officers in the pertinent aspects of physics, environmental conditions, operations analysis and other disciplines which are fundamental to translating various technological factors into operational terms.
- Provide a broad understanding of our systems and techniques of EW.
- Provide an appreciation of the vulnerabilities of these systems to exploitation and countermeasures.
- Develop officers' analytical ability to correctly assess the capabilities and proper employment of EW systems in a threat environment.
- Enhance the officers' qualifications for command at sea.

QUALIFICATIONS FOR ADMISSION — This curriculum is open only to officers of the U.S. Armed Forces and selected civilian employees of the U.S. federal government. Admission to the curriculum requires a baccalaureate deree with above average grades. Completion of mathematics through differential and integral calculus is required. Students lacking this background may matriculate via the Engineering Science Program. Although designed primarily for unrestricted line officers with established warfare qualifications, quotas may be available on a case basis for officers of the restricted line communities. Of equal importance to academic qualifications is demonstrated outstanding performance in an officer's warfare specialty. A tour of duty providing operational electronic warfare experience is also desirable but not mandatory. Officers selected for the 595 Curriculum must be eligible for security clearance permitting access to sensitive intelligence information.

DESCRIPTION — This curriculum is designed to provide an understanding of the principles underlying the broad field of electronic warfare. Because of the electronic nature of modern sensor, weapon and command, control and communication systems, this curriculum seeks to develop in the officer a grasp of electronic, electrical and electromagnetic fundamentals, theory and techniques. Another principal goal of the 595 Curriculum is to develop an ability to describe technological factors in terms which are meaningful and supportive in an operational tactical situa-

tion. To achieve these aims, preparatory material in mathematics, operations research, probability, statistics, physics and computer science are included in the program.

The 595 Curriculum is highly interdisciplinary and comprises several tracks. Inputs will occur annually in October. Each officer's transcript of prior baccalaureate study is evaluated to eliminate unnecessary duplication of previously covered material.

INTRODUCTORY CORE

This portion of the program provides a sound academic background in mathematics, computer science and technology, physics and electrical engineering. Each student's prior academic transcripts will be evaluated for validation of as many of these courses as possible. The courses which are not validated will be programmed using a nominal course load of 16-18 credit hours per quarter.

Subjects covered in the core courses include:

- Calculus and vector calculus
- Ordinary differential equations and Laplace transforms
- Fourier analysis and partial differential equations
- Probability theory
- Physics
- Electro-optics fundamentals
- Computer programming
- Real time combat direction systems
- Electronic systems
- Signals and noise
- Pulse and digital circuits
- Control systems
- Electromagnetic theory
- Decision analysis and data analysis
- Simulation and war gaming
- Meteorology

GRADUATE STUDY

The operational Electronic Warfare Curriculum qualifies the student for the degree Master of Science in Systems Engineering. During the last three quarters of this eight-quarter program the officer undertakes thesis research and preparation on a topic relevant to current military electronic warfare efforts. A program of seminars given by representatives of EW-oriented activities and industry supplements classroom instruction. Subjects covered include:

- Microwave devices and radar
- Signal processing systems
- Electromagnetic radiation, scattering and propagation
- Electronic warfare systems
- Electro-optics
- Human factors for EW
- Operations analysis
- Operational test and evaluation
- EW computer applications
- SIGINT and threat environment
- Underwater sound, systems and countermeasures
- Communications in organizations
- Naval warfare and national security
- C^3 Countermeasures

TELECOMMUNICATIONS SYSTEMS MANAGEMENT CURRICULA NUMBERS 620 AND 620CG

OBJECTIVE (SPECIFIC) — To provide instruction to officers who will perform as communications managers of new communications systems applications or as communication officers in large commands and staffs, afloat and ashore, including the organization of the Joint Chiefs of Staff and the Defense Communications Agency.

QUALIFICATIONS FOR ADMISSION — Admission to the curricula requires a baccalaureate degree with above average grades. Completion of mathematics through differential calculus is required for the 620 curriculum. The qualifications for the 620CG curriculum are the same as the 590 and 600 curricula. The student must be ready to start calculus courses on enrollment.

DESCRIPTION — The 620 and 620CG curricula are sponsored respectively by the Director of Naval Communications and U.S. Coast Guard Headquarters. Each curriculum provides comprehensive study in management, with emphasis upon the systems management field. Additionally, the curricula provide study in the technical field appropriate to decision making in advanced systems and program management. These technical courses within the 620 curriculum have been especially prepared for non-engineers whereas those in the 620CG curriculum are engineering courses. Classroom instruction is supplemented by guest lecturer seminars which afford the student an opportunity to hear discussions of communications topics by military officers and civilian executives from the Naval Telecommunications Command, Defense Communications Agency, National Security Agency and other major communication activities.

The 620 classes convene in October. Officers whose undergraduate transcripts indicate a strong background in mathematics through calculus may, on a case basis, enter a quarter early, in July, or a quarter late, in January. The 620CG curriculum begins in July. Each student's prior academic transcript is evaluated for validation of courses or for transfer of credit to cover as many courses as possible. Validation is also encouraged for courses whose content has been acquired by experience or service courses. The curricula are interdisciplinary in nature because of the wide knowledge required of the graduate. Each curriculum consists of a number of basic courses designed to provide a smooth transition from previous studies. It is required that each student follow a program of graduate level study which will yield 40 credit hours in Administrative Sciences and Quantitative Methods and 16 credit hours in Communications Systems and Computer Science. Successful completion of the program leads to the degree Master of Science in Telecommunications Systems Management. Representative subjects are listed below:

620 (Navy) Curriculum

Calculus
Statistics
Operations research
Telecommunications systems
Electronics systems
Signal transmission systems
Managerial accounting
Managerial economics
Defense resource allocation
Organizational theory
Procurement and contract administration
C3 mission and organization
Computer programming
Computer networks
Real time information systems management

620CG (Coast Guard) Curriculum

Calculus
Differential equations
Operations research
Linear programming
Circuit theory
Electronics fundamentals
Communications theory
Electromagnetic theory
Digital communications
Managerial accounting
Managerial economics
Defense resource allocation
Organization and management
Procurement and contract administration
Computer programming
Computer networks
Real time information system management
Management policy
Internal audit and control
Economics of computers
Communications satellite systems engineering

SPACE SYSTEMS ENGINEERING CURRICULUM NUMBER 591

OBJECTIVE (SPECIFIC) — To provide officers, through graduate education with a comprehensive scientific and technical knowledge in technological fields applicable to military and Navy space systems.

QUALIFICATIONS FOR ADMISSION — This curriculum is open only to officers of the U.S. Armed Forces and selected civilian employees of the U.S. federal government. A Top Secret security clearance is required with Special Intelligence (SI) clearance obtainable.

DESCRIPTION — The 591 curriculum is sponsored by the Director, Navy Space Systems Division. This curriculum is designed to equip officers with the theoretical and practical skills required to design and integrate military space payloads with other spacecraft subsystems. Officer graduates will be prepared by their education to design, develop, and manage the acquisition of space communications, navigation, surveillance, EW and environmental sensing systems. The curriculum is typically nine quarters long and begins every quarter. The graduate earns the degree Master of Science in Electrical Engineering.
in Electrical Engineering.

The curriculum includes a set of core courses and several elective tracks. The core courses include:

- Circuits and systems
- Communications theory
- Communications engineering
- Fundamentals of thermo-gas dynamics
- Statistics
- Electromagnetic radiation and scattering
- Fortran programming
- Differential equations
- Applied probability
- Electromagnetics
- Complex variables
- Logic design
- Microprocessor based system design
- Control systems
- Analysis of random signals
- Digital processing
- Introduction to space science
- Spacecraft systems
- Military applications of space
- Project management
- Satellite oceanography

Elective track include:

- Radar/EW
- Communications
- Electro-optics
- Guidance, navigation and control
- Computers
- Systems analysis
- Materials
- Heat transfer
- Structures

ENGINEERING SCIENCE PROGRAM

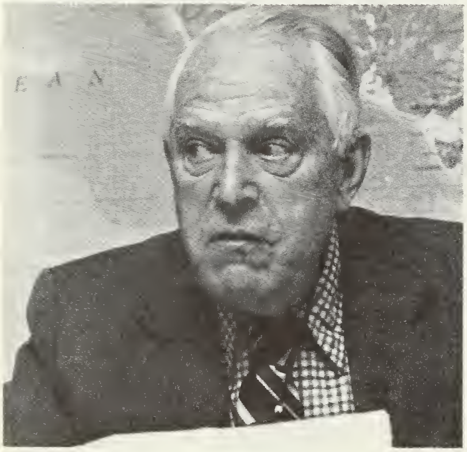
OBJECTIVE — This program is designed to provide selected officers who are deficient in mathematics, physics and basic engineering with an opportunity to qualify for admission into a graduate-level technical program at the Naval Postgraduate School.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree with a C+ average, completion of at least two pre-calculus mathematics courses with a B average, or at least one course in calculus with a C grade; and at least one course in calculus-based general physics.

DESCRIPTION — Officers ordered to the Engineering Science program are assigned to the curricular office of the graduate curriculum they have been selected to attend. Each student is evaluated on an individual basis to determine the areas of study which would be most beneficial. Course assignments are made accordingly and may include, in addition to studies in mathematics and physics, introductory courses pertaining to the designated technical curriculum.

Normal input to the Engineering Science curriculum occurs every quarter, with a planned duration of one or two quarters.

NATIONAL SECURITY AND INTELLIGENCE PROGRAMS CURRICULA NUMBERS 681, 682, 683, 684, 685, 686, 687, AND 825



James W. Mueller, Captain, U.S. Navy; Curricular Officer; B.A., Univ. of Minnesota, 1963; M.A., Naval Postgraduate School, 1977.

Linda F. Parker, Lieutenant Commander, U.S. Navy; Assistant Curricular Officer (National Security and Intelligence); Special Security Officer, B.A., Gustavus Adolphus College, 1974.

Jiri Valenta, Associate Professor of National Security Affairs; Academic Associate (Area Studies); Ing. Pol. Ek., Prague School of Economics, 1968; Ph.D., Johns Hopkins Univ., 1975.

Frank M. Teti, Associate Professor of Political Science; Academic Associate (Functional Programs); B.S., Los Angeles State College, 1960; M.A., 1962; Diploma, Institute of World Affairs, 1961; M.P.A., Syracuse Univ., 1972; Ph.D., 1966.

Joseph Sternberg, Professor of National Security Affairs; Academic Associate (Intelligence); B.S., California Institute of Technology, 1942; M.S., 1943; Ph.D., Johns Hopkins University, 1955.

NATIONAL SECURITY AFFAIRS

OBJECTIVES — These curricula are designed to provide graduate education to officers and civilian employees of the U.S. Government emphasizing: politico-military affairs, strategic and operational planning, attache affairs, intelligence and area analysis. These curricula include area specialty programs (681, 682, 683 and 685) and functional specialty programs (684, 686 and 687). Completion of any of these curricula leads to the degree of Master of Arts in National Security Affairs.

AREA SPECIALTY CURRICULA

#681 — Middle East, Africa, South Asia
#682 — Far East, Southeast Asia, Pacific
#683 — Europe, USSR
#685 — Western Hemisphere

QUALIFICATIONS FOR ADMISSION — U.S. military officers and civilian employees of the U.S. Government are eligible for admission into the area studies programs. Prospective students must be eligible for a Top Secret clearance with access to sensitive compartmented information based on a special background investigation completed within the past five years.

The entrance requirement is a baccalaureate degree earned with above average academic performance and a graduate record examination (GRE) verbal score in the upper third. Minimum QPR for admission is 3.0, which can be waived for students with a combined verbal/math GRE score of 1200 or more. College-level preparation in basic descriptive and inferential statistics is required. In addition, for those students whose sponsors require language, a minimum score of 100 on the Defense Language Aptitude Battery or language proficiency validated by the Defense Language Proficiency Test is required.

Applicants with validated language proficiency and/or undergraduate degrees in area studies, international relations, foreign affairs, international service, political science, government, public administration, history, language or psychology will be more competitive.

Specific educational skill requirements related to these area specialty curricula are:

(1) Analytical and Research Skills — Scholarly skills emphasized throughout the programs include: effective oral and written expression, research techniques, interpretation and evaluation of complex data, problem solving, forecasting, decision processes, modes of negotiation and debate, the formulation of strategy and politico-military objectives.

(2) Culture and Religion — The student should be cognizant of the influence of class structure, ethnic, cultural and religious values, and ideology on domestic and foreign affairs. They should understand the origins of current cultural and religious differences and conflicts and how these factors affect regional and national unity.

(3) Current Issues — Students must be familiar with the major security issues in the world. These include, but are not limited to, political, economic and military conflicts, insurgencies, social problems and efforts at social reform, economic problems and other issues that affect both the status or well-being of nations. These issues should be related to the formulation and implementation of U.S. foreign and security policies.

(4) Economics — Students must be aware of the economic strengths and weaknesses of the major power blocks and of economic phenomena which influence ideology, military doctrine, industrial and social development. Area specialists must be familiar with the principal resources, economic influence, industrial capacity and major industries of their world region.

(5) Geography — Students should have a grasp of geography and its impact on national development, agriculture, spatial relationships, transportation systems, economic sufficiency and military posture. Area specialists should have detailed knowledge of their geographical areas and the concomitant strategic significance.

(6) Geopolitics — Modern international politics is deeply rooted in geography. Students will be familiar with the geopolitical aspects of world regions in terms of their global strategic importance. They will understand how scholars view the influence of geography, climate, economics, political culture, and demography on political thought and foreign policy.

(7) Historical Development — The student should understand the historical trends and influences that have shaped and provide the context for interaction in today's international environment and future developments. Area specialists should acquire detailed knowledge concerning the historical developments in the region of their specialty with particular emphasis on the political evolution, traditional enemies and conflicts, regional alliances, and domestic issues.

(8) Language — Area specialists should be capable of maintaining their expertise in the given professional area. This would include the reading of newspapers and journals written in the language of the area in order to be cognizant of developments as they occur. The ideal area specialist should have intensive language training in one major language group and acquire working knowledge of a second language in his specialty area.

(9) Military Forces — Students will understand the roles, political influence, social position, composition, structure, capabilities, and vulnerabilities of the armed forces. They will be informed of current political and military developments, regional politico-military relations, and regional defense agreements, both bi- and multi-lateral.

(10) Politics — Students should have a knowledge of the major political systems, political culture and governmental organizations; be aware of current political doctrine and issues, and know the strength, appeal, and influence of communism and other ideologies. Area specialists should have a detailed knowledge of their area and be aware of the current relationships, attitudes and perspectives toward both the United States and the Soviet Union prevalent in it.

(11) Strategic Posture — Students should perceive national strengths and weaknesses that affect a nation's strategic postures and capabilities; and be able to identify and assess major military, political, economic and sociological trends which affect policy choices in domestic and foreign affairs.

DESCRIPTION — These curricula are from one to two years in length depending upon the curriculum and option selected, the language studied, and educational background. Students are assigned to NPS for the duration of the combined program, if the language study is conducted at DLI. Quotas for language instruction are obtained by the Curricular Office, except for those students who have acquired language proficiency either at DLI or other institutions before admission to the program. For those students whose sponsors do not require language instruction, a purely academic option conducted solely at NPS is offered.

Student programs are individually tailored. Course selection depends upon the student's academic and professional background, sponsor requirements, and area specialty concerned. Course mix and sequence will also vary according to the quarter of entry. Each of the three curricula is built upon a common core of four courses.

The common core provides a foundation for students in the methodological approaches to analysis of the international environment, national security issues applicable to all regions of the world, and the conduct of U.S. security affairs. Topics covered include the following:

Conceptual framework for understanding comparative politics
Theories of political development and change
Research design
Modeling factors of interstate behavior and national decision making
World trade and the international monetary system
Location and flow of strategic resources
Cross-national security assistance including arms and technology transfer
Defense decision making process
Executive/legislative interaction and influence
Perspectives on American civilization

#681 — Middle East, Africa, South Asia

Individual programs in this curriculum emphasize area studies focused on one of the three subregions in this program or contain a blend of courses applicable to all three subregions. Courses in the following areas are offered:

- Impact of geographic and oceanographic environment on military campaigns
- Communications, natural resources, and environmental factors — their impact on the African continent
- Religious and social systems of Southern Asia
- The Arabic, Judaic, Turkish and Persian traditions
- Interplay of political and social forces within the Middle East
- Internal African policies and their impact on U.S. security interests
- Soviet interests and naval expansion in the Indian Ocean
- The changing importance of Middle East oil in the world supply of energy
- Strategic problems of access to and defense of the Mediterranean littoral
- Strategic resources as determinants in great power involvement on the African continent

#682 — Far East, Southeast Asia, Pacific

Individual programs consists of a blend of courses applicable to all three of these subregions. Courses dealing with the Soviet Union, a Eurasian power and major actor throughout Asia, are included in all options. Courses in the following areas are offered:

- Historical forces relevant to modern revolutionary movements
- The great Asian religions and their role in the development of social systems
- The role of ethnic minorities and the influence of the overseas Chinese
- The transformation of Indo-China into communist states
- Present and future military capabilities and strategies of Asian states
- Nationalism, development and security in the governments of South Asia
- Crisis management and trends in Soviet foreign policy
- Forecasting international conflict in Asia
- The extent and influence of Sino-Soviet relations on other nations
- Elements of strategic geography: the political, economic, social and military applications

#683 — Europe, USSR

Individual programs emphasize area studies focused on these subregions. Courses in the following areas are offered:

- Nuclear proliferation, technology and politics
- Deterence theory and practice
- Elements of strategic geography: the political, economic, social and military applications
- The polarization of Europe into two security systems: NATO and the Warsaw Pact
- Domestic factors conditioning Soviet national security policy
- Doctrinal and functional analysis of Soviet naval strategy
- Patterns of communist takeovers and system development
- Strategic problems of access to and defense of the Mediterranean littoral
- Current issues in Soviet-European affairs

#685 — Western Hemisphere

Two major options include a six-quarter Western Hemisphere program and a Latin American option consisting of four quarters of academic courses plus instruction in an appropriate language. Individual student programs are determinded based on the area specialty, target country, and sponsor require-

ments. Courses in the following areas are offered:

- Developmental economics
- Historical forces relevent to contemporary hemispheric issues
- The role of the military in Latin America
- Role of revolutionary movements, the church, constitutionalism, and economic output as sources of social cohesion
- Attempts by countries from various parts of the world to penetrate Latin America
- United States interests in Latin America

FUNCTIONAL SPECIALTY CURRICULA

#684 — International Organizations and Negotiations

QUALIFICATIONS FOR ADMISSION — U.S. military officers and civilian employees of the U.S. Government are eligible for admission into the International Organizations and Negotiations program. Prospective students must be eligible for a Top Secret clearance with access to sensitive compartmented information based on a special background investigation completed within the past five years.

The entrance requirement is a baccalaureate degree earned with above average academic performance and a Graduate Record Examination (GRE) verbal score in the upper third. Minimum QPR for admission is 3.0, which can be waived for students with a combined verbal/math GRE score of 1200 or more. College-level preparation in basic descriptive and inferential statistics is required. In addition, for those students whose sponsors require lanproficiency, a minimum score of 100 on the Defense Language Aptitude Battery or language proficiency validated by the Defense Language Proficiency Test is required.

Applicants with validated language proficiency and/or undergraduate degrees in area studies, international relations, foreign affairs, international service, political science, government, public administration, history, language or psychology will be more competitive.

The sponsor-validated educational skill requirements call for graduates able to demonstrate a thorough understanding of:

— The national interests of the United States with a particular emphasis on security and foreign policy interests, goals and objectives.

— The interests, goals and objectives of our potential adversaries.

— Contemporary international law, law of the sea, law of war.

— The character and structure of international organizations either public or private, universal or regional.

— The character and structure of the World Court.

Graduates should also display a reasonable degree of knowledge and understanding of:

Evolutionary, Developmental, and Historical

— The historical evolution of the international system.

— The concepts of alliance, integration conflict, arms competition and arms control as they apply to interstate behavior.

— New forces operating in the international system such as transnationalism, technology, resource cartels, nuclear proliferation and changing economic orders, including the economic interdependence of underdeveloped nations.

— The history of Alliance politics within NATO and OAS.

— The historical framework of modern revolution, and current revolutionary tactics/political terrorism/political terrorism/political blackmail.

— The development of international law.

— An overview of the history of international negotiations since 1945.

— A history of arms control negotiations since 1920, with emphasis on the post 1960 period.

Policy Science: U.S. National Security Decision Making

— The formal and informal defense decision making process and its impact on national security to include:

The goals, values and priorities which underlay defense decisions.

Crisis management procedures.

The interagency coordination process.

Functions of other agencies/departments within the Executive Branch.

— U.S. and Soviet strategic doctrine.

— Elements of national power, especially military power, of the major superpowers.

The determination of regional force requirements to achieve national policy objectives.

— International defense commitments of the U.S.

— Current strategic issues including national objectives and strategic alternatives, deterrence, warfighting, counterforce, arms control, counterinsurgency, arms competition, nuclear proliferation, terrorism, etc.

— The political/strategic implications of Soviet-U.S. nuclear weapon deployments.

— The political/strategic implication of nuclear weapon deployment by other parties — UK/FRANCE/PRC — emerging states.

— Domestic contraints on U.S. foreign and defense policy.

Defense Resources

— Processes by which resources are allocated to the production of goods in the Defense sector, including the PPBS; the role of Congressional, OMB, NSC, and Presidential staffs in the defense policy/budget process; reprogramming, rescission, impoundment, etc., of defense funds.

— Trends of U.S. and Soviet security policy, military forces, manpower and capabilities including nuclear capabilities and doctrine, BMD and air defenses, civil defense, combined arms deployments, NATO-Warsaw Pact military balance, naval forces, and trends in U.S. and Soviet economies, especially as they affect the allocation of resources to defense.

— Problems related to access to global resources and utilization, agricultural production, critical raw materials, the politics of oil; national, international and strategic implication of self-sufficiency and interdependency.

— The economic and political factors that determine national and international economic arrangements including public finance, basic differences between various economic systems, and the changing world economic order.

USSR

— The Soviet/Warsaw Pact political culture, ideology, religion, political institutions, economic structures, strategic posture, military capabilities and leadership.

— The roles played by the Soviet Navy Merchant Marine, fishing fleet and oceanographic establishment including; a feeling for the geographic factors affecting Soviet ocean strategies, non-naval Soviet trends, international and domestic factors affecting post-1953 naval strategy, the development of Soviet Naval Warfare capabilities, doctrinal and functional analysis of post-1953 trends in naval strategy, command structure, personal training, law of sea positions, and U.S.-Soviet Navy interactions.

— Economic influences on Russian military operations and strategies, emphasizing the Soviet era and possible alternative future Soviet military developments and strategies.

— Internal and external processes which determine the national security and foreign policies of the Soviet Union.

— Soviet views toward the employment and use of nuclear forces, including land and maritime nuclear strategic and nuclear theater forces and weapons, in the advancement of their political and military policies.

Culture, Religion, Ideologies Contemporary Influences on International Negotiations

— The influence of class structure, ethnic, cultural and religious values, and ideology on domestic and foreign affairs. The origins of current cultural and religious differences and conflicts and how these factors affect regional and national unity.
— The major security issues in the world. These include, but are not limited to, political, economic and military conflicts, insurgencies, social problems and efforts at social reform, economic problems and other issues that affect both the status or well-being of nations. These issues should be related to the formulation and implementation of U.S. foreign and security policies.
— The economic strengths and weaknesses of the major power blocs and of economic phenomena which influence ideology, military doctrine, industrial and social development.
— The impact of geography on national development, agriculture, spatial relationships, transportation systems, economic sufficiency and military posture.
— The geopolitical aspects of world regions in terms of their global strategic importance. The influence of geography, climate, economics, political culture, and demography on political thought and foreign policy.
— The roles, political influence, social position, composition, structure, capabilities, and vulnerabilities of the armed forces. The current political and military developments, regional politico-military relations, and regional defense agreements, both bi- and multilateral.
— The student should perceive national strengths and weaknesses that affect a nation's strategic postures and capabilities; and be able to identify and assess major military, political, economic and sociological trends which affect policy choices in domestic and foreign affairs.
— International aspects of international negotiations.
— Organizational behavior in a cross-cultural, cross-institutional context.
— History and technique of diplomacy.
— Strategies of communication and bargaining.
— The concept of the operational code.

DESCRIPTION — This curriculum focuses on the security relationships between the United States and other nation states. Students address the interests of both governmental and non-governmental actions, the organization and structure through which relationships are conducted, and the development of international institutions and policies that provide guidelines for such interaction; such as international law, the law of war and the law of the sea. Courses in the following areas are offered:

The legal reasoning and source materials employed in international law
Case studies of international organizations: their utility and limitations
American goals, objectives and resources applicable to international relationships
Concepts and technical aspects of a rational ocean policy
Utility and limitations of models used in the policy sciences for analyzing the defense policy process
Oceanographic, military, political, economic and legal problems of the oceans
Arms control and disarmament
Soviet political institutions and economic structures
Viewpoints of both oil exporting and oil importing countries

STRATEGIC PLANNING
#686 — GENERAL
#687 — NUCLEAR

QUALIFICATIONS FOR ADMISSION — U.S. military officers and civilian employees of the U.S. Government are eligible for admission into the Strategic Planning programs. Prospective students must be eligible for a Top Secret clearance with access to sensitive compartmented information based

on a special background investigation completed within the past five years.

The entrance requirement is a baccalaureate degree earned with above average academic performance and a Graduate Record Examination (GRE) verbal score in the upper third. Minimum APC for the Strategic Planning Curricula is 2-4-5, which indicates a QPR of at least 3.0 on the 4.0 scale, and at least two pre-calculus mathematics courses with a B average or better. College-level preparation in basic descriptive and inferential statistics is also required. The minimum QPR can be waived for students with a combined verbal/math GRE score of 1200 or more.

The educational skill requirements call for graduates who can demonstrate a thorough understanding of:

— The generation of national military power and its employment in support of national objectives/policy in interstate relations.

— The process of U.S. strategic decision making within its political setting.

— The deployment of military forces, including maritime nuclear strategic and theater forces, in peacetime, times of crisis, and under conditions of conventional or nuclear war to meet U.S. objectives (consider the implications of such employments on existing and projected world political conditions and/or contributions made toward achieving the strategic plan/concept under implementation).

Specific educational skill requirements include the ability to:

— Analyze international relations from three perspectives; systems, nation-state, and the individual decision maker.

— Analyze current/projected politico-military situations and develop viable strategic concepts which meet U.S. national goals.

In addition, graduates should display a reasonable degree of knowledge and understanding of the following:

Evolutionary History

— The historical evolution of the international system.

— The concepts of alliance, integration conflict, arms competition and arms control as they apply to interstate behavior.

— New forces operating in the international system such as transnationalism, technology, resource cartels, nuclear proliferation and changing economic orders, including the economic interdependence of underdeveloped nations.

— The history of Alliance politics within NATO. State of the NATO Alliance in today's world.

— The historical framework of modern revolution, and current revolutionary tactics/political terrorism/political blackmail.

Strategies for National Security

— The formal and informal defense decision making process and its impact on national security to include:

— The goals, values and priorities which underlay defense decisions.

— Crisis management procedures.

— The interagency coordination process.

— Functions of other agencies/departments within the Executive Branch.

— U.S. and Soviet strategic doctrine.

— Elements of national power, especially military power, of the major superpowers.

— The determination of regional force requirements to achieve national policy objectives.

— The development of operations plans to secure strategic objectives.

— International defense commitments of the U.S.

— Current strategic issues including national objectives and strategic alternatives, deterrence, warfighting, counterforce, arms control, counterinsurgency, arms competition, nuclear proliferation, terrorism, etc.

— The political/strategic implications of Soviet-U.S. nuclear weapon deployments/employments.

— The political/strategic implication of nuclear weapon deployment by other parties — UK/FRANCE/PRC — emerging states.

Defense Resources

— Processes by which resources are allocated to the production of goods in the Defense sector, including the PPBS; the role of Congressional, OMB, NSC, and Presidential staffs in the defense policy/budget process; reprogramming, rescission, impoundment, etc., of defense funds.

— Trends of U.S. and Soviet security policy, military forces, manpower and capabilities including nuclear capabilities and doctrine, BMD and air defenses, civil defense, combined arms deployments, NATO-Warsaw Pact military balance, naval forces, and trends in U.S. and Soviet economies, especially as they affect the allocation of resources to defense.

—The time span required for weapons systems (conventional and nuclear) research, development, operational tests and service delivery.

—Role of the Department of Energy in the weapons development and production process.

—Problems related to access to global resources and utilization, agricultural production, critical raw materials, the politics of oil; national, international and strategic implication of self-sufficiency and interdependency.

—The economic and political factors that determine national and international economic arrangements including public finance, basic differences between various economic systems, and the changing world economic order.

Intelligence

— Intelligence systems and products which support command decision making.

—Soviet command and control concepts and practices, intelligence procedures, and Soviet intelligence organizations and capabilities.

The USSR

— The Soviet/Warsaw Pact political culture, ideology, religion, political institutions, economic structures, strategic posture, military capabilities and leadership.

— The roles played by the Soviet Navy, Merchant Marine, fishing fleet and oceanographic establishment including; a feeling for the geographic factors affecting Soviet ocean strategies, non-naval Soviet trends, international and domestic factors affecting post-1953 naval strategy, the development of Soviet Naval Warfare capabilities, doctrinal and functional analysis of post-1953 trends in naval strategy, command structure, personal training, law of sea positions, and U.S.-Soviet Navy interactions.

— Economic influences on Russian military operations and strategies, emphasizing the Soviet era and possible alternative future Soviet military developments and strategies.

— Internal and external processes which determine the national security and foreign policies of the Soviet Union.

— Soviet views toward the employment and use of nuclear forces, including land and maritime nuclear strategic and nuclear theater forces and weapons, in the advancement of their political and military policies.

Nuclear Warfare (Nuclear Option)

— Interrelationship of nuclear warfare considerations in conventional warfare planning including implications for battle group dispositions and strategic employment.

— Naval strike warfare (ASUW and land attack) as an element of U.S. National policy.

— Weapons effects for both conventional and nuclear weapons with emphasis on the impact of air, surface, and underwater nuclear detonations on battle groups, with implications for nuclear versus conventional weapon targeting. Weapons effects on strategic communications.

— Soviet-U.S. theater nuclear capabilities and defenses to include implications regarding nuclear warfighting capabilities, and the potential outcome of a U.S.-Soviet nuclear war.

— Basic targeting theory including im-

pact of footprinting/weapon ranges resulting from uploading/downloading/MIRVing various missiles.
— Hardness factors, prelaunch survivability and the significance of changes on PLS, increased accuracy, throw-weight, etc.
— The background and impact of all aspects of nuclear arms limitations, CTB, and verification confidence.
— The concept and principles of deterrence, assured destruction, essential equivalence, launch on warning, counterforce and countervailing strategy, residual/reserve forces, controlled escalation, and national nuclear targeting.
— U.S. organization for nuclear warfare. Political and military decision making on nuclear matters.
— Strategic Command, Control, Communications and Intelligence including NMCS, NMCC, emergency action procedures, communications systems and trans/post strike reconnaissance, C3I reconstitution capabilities, etc.

Management and Planning Systems

— Probability and statistics for management applications, including probability models, discrete and continuous random variables, sampling theory and an introduction to statistical inference.
— Computer theory for management applications, war gaming and decision analysis.
— Techniques of decision analysis statistics and data analysis.
— The man-machine interface in C^3
— The employment of simulation and war gaming techniques as primary tools in the naval planning process.
— The joint military operations planning system and operational requirements for C^3 systems.

DESCRIPTION — These curricula focus on major issues and U.S. security affairs with equal emphasis. The major thrust is the evolution of military capabilities, force employment and contingency situations. Courses in the following areas are offered:

Prerequisites for analysis of defense budgets
Modern revolution and political terrorism
Technological and political influences of nuclear weapons
Factors dominating the arms transfer policies of the major powers
Impact of arms transfers on regional conflict and economic development
Strategic context of American national security policy
The role of OMB, NSC, and the Presidential Staff
Forecasting the influence of technology on public policy
Access to critical raw materials and defense of trading routes
Threat analysis and net assessment
Systematic strategic resource analysis
The political, military and economic issues in Europe since 1945
Impact of oil revenues on Middle Eastern regional development and military balance
Crisis management and trends in Soviet foreign policy
Modeling Soviet and U.S. naval interaction
Western and Soviet interests in the Mediterranean and the policies of surrounding states

INTELLIGENCE

OBJECTIVES — This curriculum is designed to provide a broad graduate level education in the natural and applied sciences, national security affairs, analytical skills, information management techniques, and intelligence procedures and products in order to further creative application of these disciplines to the intelligence process. Completion of this curriculum leads to the degree Master of Science.

INTELLIGENCE CURRICULUM #825

QUALIFICATIONS FOR ADMISSION — U.S. military officers and civilian employees of the U.S. Government

are eligible for admission into the Intelligence program. Prospective students must be eligible for a Top Secret clearance with access to sensitive compartmented information, based on a special background investigation completed within the past five years.

The entrance requirement is a baccalaureate degree earned with above average academic performance. Minimum APC for the Intelligence Curriculum is 3-3-4, which indicates a QPR of at least 2.20 on the 4.0 scale, at least one calculus course with grade C or better, and one calculus-based physics course with grade C or better. In addition, college-level preparation in basic descriptive and inferential statistics is required. All students will report for refresher in mid-February or mid-August for the spring or fall curriculum start dates. During refresher, students receive accelerated calculus and physics review courses, plus a structured introduction to NPS computer resources.

The following educational skill requirements have been identified for the Intelligence Curriculum:

Defense Technology

ACOUSTICS — A working knowledge of acoustic propagation in seawater, acoustic detection systems and their properties, and the effects of oceanographic and other related factors on submarine detection.

ELECTROMAGNETICS — A working knowledge of basic electromagnetic theory necessary to understand communications and radar systems.

COMMUNICATIONS AND ELECTRONICS — A basic knowledge of the principles and applications of communication, signal intercept, and other electronic systems; their capabilities and limitations; the impact of the environment, electronic countermeasures, and other factors on their operation; and the development and application of such systems by the Soviet Union.

AEROSPACE AND MISSILE TECHNOLOGY — A basic knowledge of the aerodynamics and physics applying to the design and functioning of aircraft, missiles, and space systems. An appreciation of the potential uses of space platforms for intelligence and other military purposes.

RESEARCH AND DEVELOPMENT — A basic understanding of the process of weapons design, development, and testing, with application to technological forecasting.

WEAPONS SYSTEMS — A basic understanding of weapons as interdependent systems; of the tradeoffs which can be made within and between systems; and techniques for measuring the characteristics, capabilities, and effectiveness of weapons systems.

Analytic Tools

BASIC MATHEMATICS — A working knowledge of the basic mathematics needed for successful completion of the probability and statistics, operations analysis, and computer applications courses, as well as for understanding of acoustic signal propagation, electromagnetic signal propagation, information processing, and engineering design practices.

QUANTITATIVE ANALYTIC TECHNIQUES — A basic knowledge of probability and statistics, operations analysis, and other quantitative techniques applicable to problem solving in intelligence.

USE OF THE COMPUTER — A working knowledge of the basic capabilities and limitations of computers; familiarity with computer-related terminology, elements of computer languages and programming, interface between man and computer, and trends in computer development.

APPLICATION OF THE COMPUTER TO INTELLIGENCE — A basic knowledge, derived partly through hands-on experience, of the characteristics of computer accessed intelligence data bases (e.g. COINS, DIAOLS, intelligence segments of WWMCCS etc.)

and applications of the computer to manipulating data, displaying data, performing quantitative analyses, and solving problems.

BASIC RESEARCH TECHNIQUES - A working knowledge of the basic sources of open and classified information; of how to retrieve, organize, and analyze information for various purposes, including net assessments and forecasts, and gaming, simmulation, and modeling; of how to use basic analytical tools such as time lines and graphic displays; and of how to present findings in both written and oral form.

Security Affairs

FORMATION OF US NATIONAL SECURITY OBJECTIVES AND POLICIES — A working knowledge of the policy formation process; of the actors who participate in it (including intelligence agencies); the roles they play; the inputs into the process; the main policies and programs which have resulted from it since World War II; the mechanisms or procedures which convert inputs into policies and programs; budgetary, threat, and other environmental factors affecting the process; the impact of the process on the performance of intelligence.

NATIONAL SECURITY OBJECTIVES OF THE SOVIET UNION — A basic knowledge of the structure of Soviet society and government; of Marxist-Leninist philosophy; of the Soviet process for formulating and implementing national security objectives and policies; of the factors affecting that process; of the structure and purpose of the Soviet military and its strengths and limitations.

SOVIET MILITARY DOCTRINE AND STRATEGY — A working knowledge of the basic tenets of Soviet military doctrine and strategy; the Soviet military mind-set; contrasts with U.S. military thought and strategy; the impact of geographical, historical, ethnic, political, and economic influences; the role of the Soviet Navy in overall Soviet military strategy; the Soviet military establishment as an expression of Soviet national objectives and aspirations.

THE SOVIET NAVY — A working knowledge of the composition, capabilities and limitations of the Soviet Navy; its doctrine and strategy; its utilization in peacetime and war; its missions and functions; projections for the future role and capabilities; comparisons with Western maritime capabilities; relationship of the Navy to the merchant marine and fishing fleets and other related maritime endeavors.

Professional Development

ORGANIZATION AND FUNCTIONING OF INTELLIGENCE IN THE U.S. — A basic knowledge of the structure of the U.S. intelligence community; intelligence organizations; terminology; the workings of military and naval intelligence; the intelligence cycle; the application of intelligence to military and naval operations.

INTELLIGENCE SYSTEMS AND PRODUCTS — A basic knowledge of present intelligence systems and products, and of their strengths and limitations; of C3I architecture; of possible and projected future systems; of the analytical procedures by which raw intelligence is converted into finished intelligence; and of how intelligence requirements are derived.

THREAT ANALYSIS — A basic knowledge of the threat and of methods for quantifying, forecasting, and assessing its significance; of the effect of cultural and organizational biases on threat analysis; and of the lessons to be learned from historical case studies.

DESCRIPTION — The Intelligence Curriculum is an interdisciplinary program which integrates political science, mathematics, operations analysis, oceanography, aeronautical engineering, electrical engineering, physics, information systems, and managerial economics into an understanding of intelligence. Approximately half of

the coursework in this technical (non-engineering) curriculum is undertaken in Naval Postgraduate School academic departments under the Dean of Science and Engineering; the remaining courses are in the information and policy sciences.

Coursework addresses three broad fields: defense technology, analysis and management, and national security affairs. The defense technology courses are designed to address the special problems of technical intelligence, emphasizing technical literacy and the ability to communicate concerning technological and environmental problems. This sequence seeks to provide the perspective that will assist assessment of the reliability and significance of technical and environmental data, as well as ensure familiarity with the resources in these fields that may be applied to intelligence problems.

The analysis and management coursework provides the student with a grounding in quantitative techniques, substantive research methods, and the concepts of resource management. Students are introduced to various means to structure given problems, formulate possible solutions, organize and compile supporting data, assess the reliability, and communicate the significance of the results obtained.

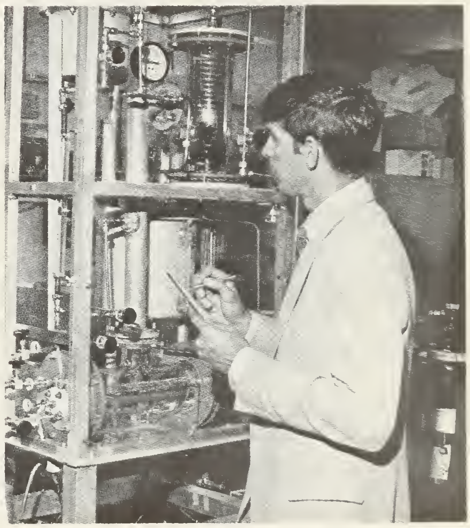
Graduate courses in National Security Affairs outline the interface between international politics, national security objectives, resource management and weapons technology. The sequence synthesizes the political, technological, economic, cultural, social and ideological forces that influence the actors in the international system and models varying scenarios of interaction between them.

Programs for students in the Intelligence Curriculum are individually tailored to suit each student's background, interests, and potential assignments while fulfilling the educational skill requirements. Every student's program must be approved by the academic associate and the curricular officer. A student with an appropriate background may validate any course in the standard curriculum, allowing omission of that course from the student's program. However, no credit will be granted for a course that has been validated. The basic purpose of course validation is to make optimal use of the student's time at Naval Postgraduate School. Validation allows the student to concentrate in greater depth in a certain area, or to choose courses from areas not covered by the standard curriculum, to broaden his or her background.

NAVAL ENGINEERING PROGRAM
CURRICULUM NUMBER 570

Walter Alfred Ericson, Captain, U.S. Navy; Curricular Officer; B.S., U.S. Naval Academy, 1964; M.S.M.E. and Mechanical Engineer, Naval Postgraduate School, 1972.

Robert Harry Nunn, Professor of Mechanical Engineering (1968); Academic Associate; B.S., Univ. of California at Los Angeles, 1955; M.S.M.E., 1964; Ph.D., Univ. of California at Davis, 1967.



CURRICULUM NUMBER 570

OBJECTIVES — To provide graduate education, primarily in the field of Mechanical Engineering. The graduate will have the technical competence to operate and maintain modern warships and naval systems. He will be able to participate in technical aspects of naval systems acquisition and be able to recognize applications for technological advances in naval ships and systems. Through emphasis on the design aspect within the program, the graduate will be well prepared to apply these advances in technology to the warships of the future.

ENTRANCE DATES — March and October are best for effective program scheduling; however, classes convene any quarter.

QUALIFICATION FOR ADMISSION — A baccalaureate degree or its equivalent in engineering or the physical sciences is required. Mathematics through integral calculus plus one year of physics are non-waiverable requirements. The Engineering Science program (Curriculum Number 460) is available for candidates who do not meet all admission requirements. The additional time required will vary with the candidate's background.

DESCRIPTION — The academic program is grouped into an introductory study portion and an advanced graduate level study portion. The introductory study program consists of undergraduate and graduate level courses which provide the necessary breadth and depth for successful pursuit of the advanced graduate level study portion of the program. Each student's transcript is evaluated for validation of as many of the introductory study courses as possible and the student is interviewed upon arrival to reach a final decision on those courses to be programmed for the introductory study program. This portion of the curriculum includes courses in the following areas:

Calculus review
Linear algebra and vector analysis
Computer programming
Ordinary and partial differential equations/complex functions
Statics and dynamics
Mechanics of solids
Engineering thermodynamics
Fluid mechanics
Electrical engineering fundamentals
Naval architecture

Graduate Introductory Study

Heat transfer
Advanced mechanics of solids
Mechanical vibrations
Marine power systems
Nuclear power systems
Intermediate fluid mechanics
Design of machine elements
Marine gas turbines
Engineering numerical analysis
Properties of structural materials
Quality assurance and reliability

Advanced Graduate Study

After completion of the introductory study portion of the program, a coherent sequence of electives are selected from the advanced graduate level courses. These are chosen in consultation with the Curricular Officer and faculty advisors. A normal program of study leading to the degree Master of Science in Mechanical Engineering will allow for elective courses chosen from the following extensive list:

FLUID MECHANICS
Viscous flow
Fluid power control
Naval hydrodynamics
Compressible flow

HEAT TRANSFER
Applications of heat transfer
Conduction and radiation
Convection
Radiation heat transfer

MARINE ENGINEERING
Marine propulsion control systems
Marine vehicle design
Marine engineering design
Marine gas turbines
Dynamics of marine vehicles

MATERIALS SCIENCE
Phase transformation
Advanced engineering materials
Mechanical behavior of engineering materials

NUCLEAR ENGINEERING
Nuclear reactor analysis
Reactor engineering principles and design

SOLID MECHANICS
Advanced mechanics of solids
Finite element methods
Theory of continuous media
Advanced dynamics
Engineering design optimization

SHOCK AND VIBRATION
Vibration, noise, and shock
Random vibrations and spectral analysis

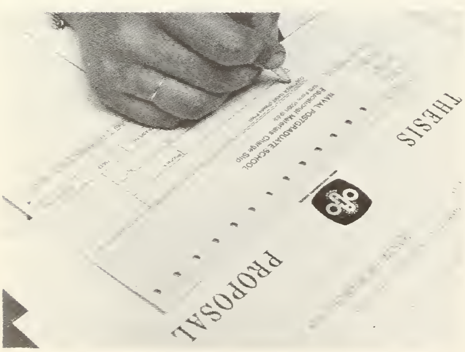
Availability of a graduate course may be dependent on student loading at the time the course is desired. In special cases, an advanced topics program in the subject area of interest may be arranged between the professor and student.

THESIS — An original research project resulting in a finished thesis is an integral part of the curriculum. The schedule of classes is arranged to provide time during the final two quarters for concentration in this area of specialization. Topics are selected in the fifth quarter of the students' program for approval by the Chairman, Department of Mechanical Engineering. A faculty advisor is assigned for consultation in designing and conducting a program of research. Considerable emphasis is placed on the production of a quality thesis.

ADVANCED DEGREES — The Naval Engineering program is designed to lead to the degree of Master of Science in Mechanical Engineering. A limited number of particularly well qualified students may be able to further their education beyond the master's level and seek the degree of Mechanical Engineer. Additional courses are chosen from the list of advanced graduate courses and a thesis of greater scope and depth is required. The additional time required to meet the requirements for the Mechanical Engineer degree will vary with the individual's progress at the time of entry into the advanced program. Criteria for selection include superior academic performance, tour availability, and a demonstrated capability to perform in the environment of the professional engineer. A program leading to the Doctor of Engineering or the Doctor of Philosophy degree can also be made available to the truly outstanding student who can qualify as a candidate for this most demanding course of study. The principle governing factor in the availability of a doctoral study opportunity is the requirement of the Navy to meet billet requirements at the time of application.

SUBSPECIALTY CODE — Those officers successfully completing these programs will be identified as subspecialists in accordance with the current instructions.

OPERATIONS ANALYSIS PROGRAMS
CURRICULUM NUMBER 360



Thomas E. Halwachs, Commander, U.S. Navy, Curricular Officer; B.S., U.S. Naval Academy, 1969: M.S., Naval Postgraduate School, 1976.

Robert Richard Read, Professor of Operations Research; Academic Associate; B.S., Ohio State Univ., 1951; Ph.D., Univ. of California at Berkeley, 1957.

OPERATIONS ANALYSIS CURRICULUM NUMBER 360

OBJECTIVE — To supply the Services' needs for a cadre of military operations analysts for assignment to Department of Defense headquarters staffs, other major staffs, development groups, operational staffs and various Defense Department agencies.

This program provides education in the application of quantitative analyses to operational, tactical, and managerial problems. The disciplines of mathematics, probability, statistics, economics, human factors, physical science, and optimization which the officer student learns here or brings with him, supply the theoretical background for analyzing alternative choices in tactical and strategic warfare and in planing, budgeting and procurement of systems and forces. The course of study generates computational capability and develops skills in identifying relevant information, generating decision criteria, and selecting alternatives. This education enhances performance in all duties throughout a military career, including operational billets, technical management assignments and policy making positions.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree with above average grades in mathematics is required. Completion of mathematics through calculus is considered minimal preparation. A one year course in college physics is highly desired. Students lacking these quantitative prerequisites will be accepted, in certain

cases, where their under-graduate records indicate that they are exceptional students and there are other possible indicators of success such as Graduate Record Examination scores, correspondence or extension courses in quantitative subjects, and outstanding motivation for the program.

ENTRANCE DATES — March and October.

DURATION — Tailored to the students's qualifications; generally two years, maximum two and one half years.

DEGREE — Requirements for the degree Master of Science in Operations Research are met as an included part of the curricular program.

DESCRIPTION — The Operations Analysis programs are technically oriented and interdisciplinary in nature, consisting of two phases: an introductory first phrase made up of basic undergraduate and graduate level courses required as prerequisities for advanced studies, and a second advanced phase which permits the student to examine a selected option area of analysis in depth. After a period of refresher course work of length dependent upon reporting date and academic background, lasting up to a maximum of six months, the first phase commences consisting of courses required of all Officer students designed to develop the fundamental skills essential to the Operations Analysis field of study. On occasion, course validation during this period allows students to take follow on courses early allowing for more elective choices later in the program. The second phase is then tailored to the curricular objectives, the Officer student's area of academic interest, and the requirements of the parent service or organization.

INTRODUCTORY STUDY

The introductory phase prepares students in the following disciplines:

- Calculus
- Linear algebra
- Computer programming in FORTRAN
- Probability and statistics
- Linear programming
- System simulation
- Human factors in systems design
- Introduction to military operations research

GRADUATE STUDY

Core Courses

The advanced phase commences with required courses in the following disciplines:

- Economic analysis
- Systems analysis
- Combat models and games
- Stochastic models
- Data analysis
- Nonlinear and dynamic programming
- System simulation
- Tactical analysis

EXPERIENCE TOUR — During the early part of the advanced phase the U.S. student is assigned a six-week experience tour with Department of Defense analysts and other groups engaged in analyses of military problems. International students are assigned experience tours consistent with classification considerations and their country's desires and at no cost to the U.S. government. Some agencies which have participated in the experience tour program in the past include:

- Office of the Chief of Naval Operations
- Office of the Secretary of Defense
- Joint Chiefs of Staff
- Center for Naval Analyses
- Naval Safety Center
- U.S. Army Concepts Analysis Agency
- Marine Corps Tactical Systems Support Activity
- Naval Systems Commands
- Operational Test and Evaluation Force
- U.S. Army Combined Arms Development Activity
- Navy Recruiting Command
- U.S. Army Operational Test and Evaluation Agency

Destroyer Development Group
Submarine Development Group
Project Managers under the Chief of Naval Material

THESIS RESEARCH — A thesis is required in addition to the course work. A total of 8 quarter hours are allocated for thesis research during the last half of the student's program.

ELECTIVE COURSES — At the completion of the experience tour the student may choose electives from course sequences which offer specialization in a particular area in recognition of requirements of the officer's military service or corps, as well as his background and interests:

Naval Warfare — Preparation for dealing with the analysis of tactics and hardware in Naval warfare. Courses include:

- Search theory and detection
- Operations research problems in naval warfare
- Tactical design and analysis
- Skilled operator performance
- Test and evaluation
- War gaming and simulation
- Design of experiments
- Radiation systems
- Weapons systems and weapons effects
- Reliability and weapons system effectiveness
- Campaign analysis
- Applications of search, detection and localization models to ASW

Land Combat — Preparation for dealing with the analysis of land combat operations. Courses include:

- Army operations research
- Land combat models
- Combat analysis
- Test and evaluation
- Games of strategy
- Campaign analysis
- Design of experiments
- Reliability and weapons system effectiveness

Systems Analysis — Preparation for dealing with defense department resource allocation, planning, and programming. Courses include:

- Theory of systems analysis
- Econometrics
- Defense expenditure and policy analysis
- Cost estimation
- Campaign analysis
- Defense systems acquisition
- Defense resource analysis
- Project management

Human Factors — Preparation for dealing with human performance evaluation and the design of man/machine systems. Courses include:

- Skilled operator performance
- Operations research in military man/machine systems
- Evaluation of human factors data
- Human performance evaluation
- Design of experiments

Logistics — Preparation for dealing with supply systems for Navy Supply Corps and Quartermaster or Maintenance officers. Courses include:

- Inventory theory
- Military supply systems
- Financial and managerial accounting
- Time series analysis
- Military procurement and contract administration
- Military application of management information systems
- Physical distribution in supply systems
- Logistics engineering

Advanced Modeling — Preparation for dealing with the theory and techniques of operations research. Courses include:

- Design of experiments
- Network flows and graphs
- Stochastic models
- Regression models
- Advanced probability and statistics
- Reliability and weapons system effectiveness
- Inventory theory
- Games of strategy
- Mathematical programming
- Decision theory
- Time series analysis

WEAPONS ENGINEERING PROGRAMS CURRICULA NUMBERS 530, 531, 532 AND 535

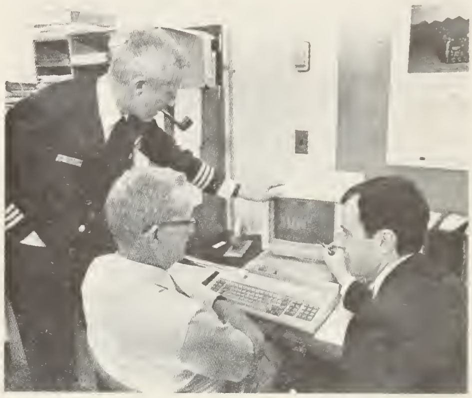
Herbert Bramwell Shaw, III, Commander, U.S. Navy; Curricular Officer; B.A., Univ. of New Hampshire, 1965; M.S.E.E., Naval Postgraduate School, 1973.

James Vincent Sanders, Associate Professor of Physics (1961); B.S., Kent State Univ., 1954; Ph.D., Cornell Univ., 1961.

Several curricular programs are administered by the Weapons Engineering Curricular Office as follows:

530 Weapon Systems Engineering
531 Weapon Systems Science
532 Nuclear Physics (Weapons & Effects)
535 Underwater Acoustics Systems

OBJECTIVE — The fundamental task of the Weapons Engineering subspecialty community is the design, development, test and evaluation, acquisition, operation and support of naval weapon systems. The weapons subspecialist's career pattern must be both technically and operationally sound in order to provide that happy combination of operational and engineering expertise. In support of this career pattern, the objective of these curricula at the Naval Postgraduate School is to provide that advanced technical education on a broad foundation encompassing the basic scientific, analytic and engineering principles underlying the field of naval weaponry. The specific areas of study and the levels of expertise to be attained are formulated for each curriculum to insure a sound basis for technical competence and for subsequent growth as may be required to support the fundamental task of the community.



This education enhances performance in all duties throughout a naval career including operational billets, technical management assignments, and policy making positions, thereby preparing the officer for increased responsibility including command, both ashore and afloat.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree with mathematics through differential and integral calculus and a calculus-based basic physics sequence are required for direct input. Courses in the physical sciences and engineering are highly desirable. Officers not having the required qualifications for direct input enter the program indirectly through the Engineering Science Curriculum discussed elsewhere in this catalog.

Officers may enhance their selectability by taking off-campus courses, including participation in the Postgraduate School Continuing Education program which has been outlined earlier in the catalog.

Allied officers may enroll in the above curricula subject to the exclusion of classified courses as determined by the Chief of Naval Operations.

DESCRIPTION — The structure of each curriculum takes into account the fact that the typical officer student has been away from an academic environment for some time and is not usually prepared to engage in graduate studies without some preparation. The extent of the preparation will depend upon the academic background of the individual officer and will be decided upon by the officer student in consultation with his Curricular Officer and Academic Associate.

The curricula described below are interdisciplinary in nature because of the broad knowledge required of the graduate. Each curriculum consists of a number of basic courses designed to provide a smooth transition from previous studies. In a typical program the first five quarters are devoted to the basic "core" material. Certain undergraduate portions of this core may be validated by an academically prepared officer to permit study to greater depth or breadth at the graduate level, or, subject to course scheduling limitations, to shorten his time on board. The remainder of the program is dedicated to advanced graduate specialization in a specific technical field. Upon successful completion of an approved curriculum, officers will be assigned the appropriate Weapons Engineering subspecialty billet code and will be awarded the degree Master of Science in the appropriate discipline dependent upon academic achievement and successful completion of all requirements. On-going counseling is provided by the Curricular Officer/Academic Associate team for all officer students and a close professional relationship between officer student and faculty enables each officer to make his time at the School a valuable asset to his professional development and career.

Descriptions of each curriculum and typical programs follow. Specific degree requirements may be found under the appropriate departmental section of the catalog.

WEAPONS ENGINEERING

Graduate education in weaponry and ordnance systems has long been one of the primary functions of the Naval Postgraduate School. As weapons systems have become increasingly complex, the need to keep pace with the rapidly emerging technology which governs the development and operations of these systems has never been greater. In order to optimally operate, manage and command these complex combat systems, it is essential that officers possess a wide range and depth of basic scientific knowledge in areas such as electronics, controls, lasers, electro-optics, computer systems, communications, radars, signal processing, materials science, explosives and propellants, plasmas, and nuclear science. The Weapons Engineering programs provide graduate-level education in these and other areas of required expertise.

In addition to the formal course work and laboratories, officer students participate in and report on projects designed to investigate components of major weapons systems in order to coordinate and reinforce their experience and their education in considering the "real-life" aspects of weapons systems engineering.

A guest lecture and seminar program, plus visits to weapon-related field activities, serve to keep students informed of current developments and stress the present day utilization of theory and technology.

INTRODUCTORY AND CORE COURSES

The Weapon Systems Engineering and the Weapon Systems Science curricula closely parallel each other for the first year (4 quarters). The variation between these two curricula is achieved by means of different and varied specialization areas during the last five quarters.

The core portion of the program provides basic mathematical, scientific and engineering courses required for successful pursuit of the graduate electives, as well as those graduate studies required of all officer students. Each student's transcript will be evaluated for validation of as many of the introductory courses as possible. The remaining courses will be programmed with a normal load of four courses each quarter.

The core courses, including some undergraduate level studies, typically cover the following areas:

- Multivariable calculus (MA 1116)
- Linear Algebra and vector analysis (MA 2047)
- Differential equations (MA 2121)
- Statistics for science and engineering (OS 3104)
- Review of basic physics (PH 1041)
- Electrical engineering (EE 2107)
- Digital machines (EE 2810)
- Linear systems (EE 2402)
- Control systems (EE 2411)
- Radar systems (EE 3431)
- Particle mechanics (PH 2151)
- Mechanics of extended systems (PH 3152)
- Thermodynamics (PH 2551)
- Modern physics (PH 2251)
- Atomic physics (PH 3651)
- Fluid dynamics (PH 3161)
- Explosives and explosions (PH 3461)
- Structured programming with PL/1 (CS 2960)
- Computer architecture (CS 3201)
- Computers in combat systems (CS 3550)
- Material science (MS 3201)

WEAPON SYSTEMS ENGINEERING CURRICULUM 530

DESCRIPTION — This program is designed to meet the needs of the military services for an officer having a strong broad-based technical education with particular applications toward weapons systems.

In addition to the introductory and core material previously described, an in-depth option sequence of normally five courses is offered wherein students specialize in particular technical subject areas. Students also engage in thesis research in an area related to these advanced studies.

Graduates are normally awarded the degree Master of Science in Engineering Science. On a case basis, some students, dependent on option courses and undergraduate background, may earn a Master of Science degree in Physics or one of the Engineering disciplines.

In view of the breadth of the 530 curriculum that addresses all aspects of weaponry, successful graduates, regardless of option, will receive the Weapons Systems Engineering subspecialty XX61P.

Courses specific to the 530 curriculum include:

- Fourier analysis of signals and systems (EE2401)
- Electromagnetic wave propagation (PH 3360)
- Failure analysis and prevention (MS 3202)
- Missile flight analysis (AE 3711)
- Missile systems design and integration (AE 4712)

GRADUATE SPECIALIZATION

For the officer pursuing the Weapon Systems Engineering program, a number of graduate options are available. The availability of these graduate sequences is dependent upon the student's academic qualifications and course scheduling feasibility. Commonly pursued areas of advanced study are:

- Control systems
- Military radar and electronic countermeasure systems
- Electro-optics and laser technology
- Materials science
- Engineering mechanics and analysis
- Military communications theory
- Computer applications to military systems
- Tactical missile design

Other specialization sequences can be designed to meet specific needs, within the limitations of available time and resources.

This curriculum commences each March and October.

WEAPON SYSTEMS SCIENCE CURRICULUM 531

DESCRIPTION — This program is designed to meet the needs of the military services for officers who have a strong broad-based technical education with graduate emphasis in engineering physics and its applications.

In addition to the introductory and core courses previously described, all students in this curriculum take additional courses in electromagnetic phenomena and statistical physics. Indepth option sequences of two or more courses are offered wherein students specialize in a particular area of physics. Students also engage in thesis research in an area related to these advanced studies.

Graduates of this curriculum are awarded a degree of Master of Science in Physics. By successful completion of the curriculum the student also earns the XX63P (Physics) subspecialty code.

Courses specific to this curriculum (and the 532 curriculum) include:

- Optics (PH 2265)
- Electromagnetism (PH 2351)
- Electromagnetic waves (PH 3352)
- Advanced electricity and magnetism (PH 4363)
- Quantum mechanics (PH 3951)
- Statistical physics (PH 3561)

GRADUATE SPECIALIZATION

For the officer pursuing the Weapon Systems Science program, several graduate options are available. These include:

- Electro-optics (PH 3952)
- Sensors, signals, and systems (PH 4952)
- Laser physics (PH 4283)
- Plasma physics (PH 4661)
- Particle beams and high-energy laser weapon systems (PH 4954)
- Orbital mechanics (PH 3112)
- Physics of the satellite environment (PH 4953)
- Nuclear physics (PH 3855)
- Physics of nuclear explosions (PH 4856)
- Semiconductors (PH 4751)
- Solid state physics (PH 4760)
- Classical electrodynamics (PH 4371)
- Relativity and cosmology (PH 4991)
- Acoustic wave propagation PH 3421)
- Sound propagation in the ocean (PH 4453)

This curriculum commences each March and October.

NUCLEAR PHYSICS (WEAPONS & EFFECTS) CURRICULUM 532

DESCRIPTION — This program is designed to meet the needs of the naval service for officers who have a broad technical education with a graduate specialization in the physics of nuclear weapons and weapons effects.

This curriculum contains the same core courses as the Weapon Systems Science Curriculum described above.

The graduate specialization sequence consists of a series of courses in the area of nuclear physics, effects of nuclear explosions, hardening technologies

and nuclear warfare analysis. Students can also take elective courses in this or related areas and are expected to engage in thesis research in their field of specialization.

Graduates of this curriculum will be awarded the degree of Master of Science in Physics. By successful completion of the curriculum, the student also earns the XX67 (Nuclear Physics) subspecialty code.

Courses in this curriculum include those in the 531 curriculum plus the following:

Nuclear physics (PH 3855)
Physics of nuclear explosions (PH 4856)
Nuclear weapon effects and hardening techniques (PH 4857)
Nuclear warfare analysis (SE 4858)

UNDERWATER ACOUSTICS SYSTEMS CURRICULUM 535

DESCRIPTION — Underwater Acoustics Systems is an interdisciplinary program. Courses are drawn principally from the fields of physics, electrical engineering, computer science and mathematics. Although broadly based, the emphasis is on underwater acoustics and signal processing applications to undersea warfare. As can be seen in the following list, courses included relate to the generation and propagation of sound in the ocean, military applications of underwater sound and the electrical engineering and computer science aspects of signal processing in sonar systems. Also included are topics concerning the effects of the noise environment on people.

Specific coverage is provided in such areas as propagation of sound in the sea, transducer theory, signal processing electronics, computer software engineering, oceanography, and noise and vibration control. Successful completion of the curriculum permits the graduate to address the current and future military problems associated with underwater acoustics systems and to expand his base of professional knowledge and technical competence.

As an integral part of his program, each officer prepares a thesis under the guidance of a faculty member. Graduates earn a degree Master of Science in Engineering Acoustics.

In addition, the program includes short field trips, visits to facilities working on current military acoustic problems, and participation in such meetings as the Navy Symposium on Underwater Acoustics.

Within the Navy, successful completion leads to an approved subspecialty code of XX56P and thus qualifies the graduate officer for assignments to challenging subspecialty billets throughout the military establishment.

A doctoral program leading to the degree Doctor of Philosophy or Doctor of Engineering in Engineering Acoustics is also available for qualified officers. For details see descriptions of programs in Engineering Acoustics elsewhere in this catalog.

INTRODUCTORY STUDY

This portion of the program provides the necessary mathematics, electrical engineering, and physics required for successful pursuit of the graduate curriculum. Each student's transcript will be evaluated for validation of as much material as possible. The remaining studies will be scheduled with a normal load of four courses each quarter.

Multivariable calculus (MA 1116)
Linear algebra and vector analysis (MA 2047)
Differential equations (MA 2121)
Review of basic physics (PH 1041)
Oscillations and waves (PH 2119)
Electrical engineering (EE 2107)
Electronic engineering (EE 2211 & EE 2212)
Fourier analysis of signals and systems (EE 2401)
Linear systems (EE 2402)
Digital machines (EE 2810)
Communication theory (EE 2500)
Structured programming with PASCAL (CS 2970)
Applied probability (OS 2102)

GRADUATE STUDY

The graduate portion of the program includes courses in the following areas:

- Methods of theoretical physics (PH 3190)
- Fundamentals of acoustics (PH 3451)
- Underwater acoustics (PH 3452)
- Noise, shock, and vibration control (PH 3458)
- Physics of underwater vehicles (PH 3166)
- Sound propagation in the ocean (PH 4453)
- Oceanic factors in underwater sound (OC 3261)
- Transducer theory and design (PH 4454)
- Analysis of random signals (EE 3500)
- Digital signal processing (EE 3400)
- Decision and estimation theory (EE 4572)
- Sonar systems engineering (EE 4451)
- Data structures (CS 3300)
- Programming languages (CS 3111)
- Computer architecture (CS 3201)
- Software development methodology (CS 3460)

Students can enter this curriculum annually in March and October.

CURRICULA CONDUCTED AT OTHER UNIVERSITIES

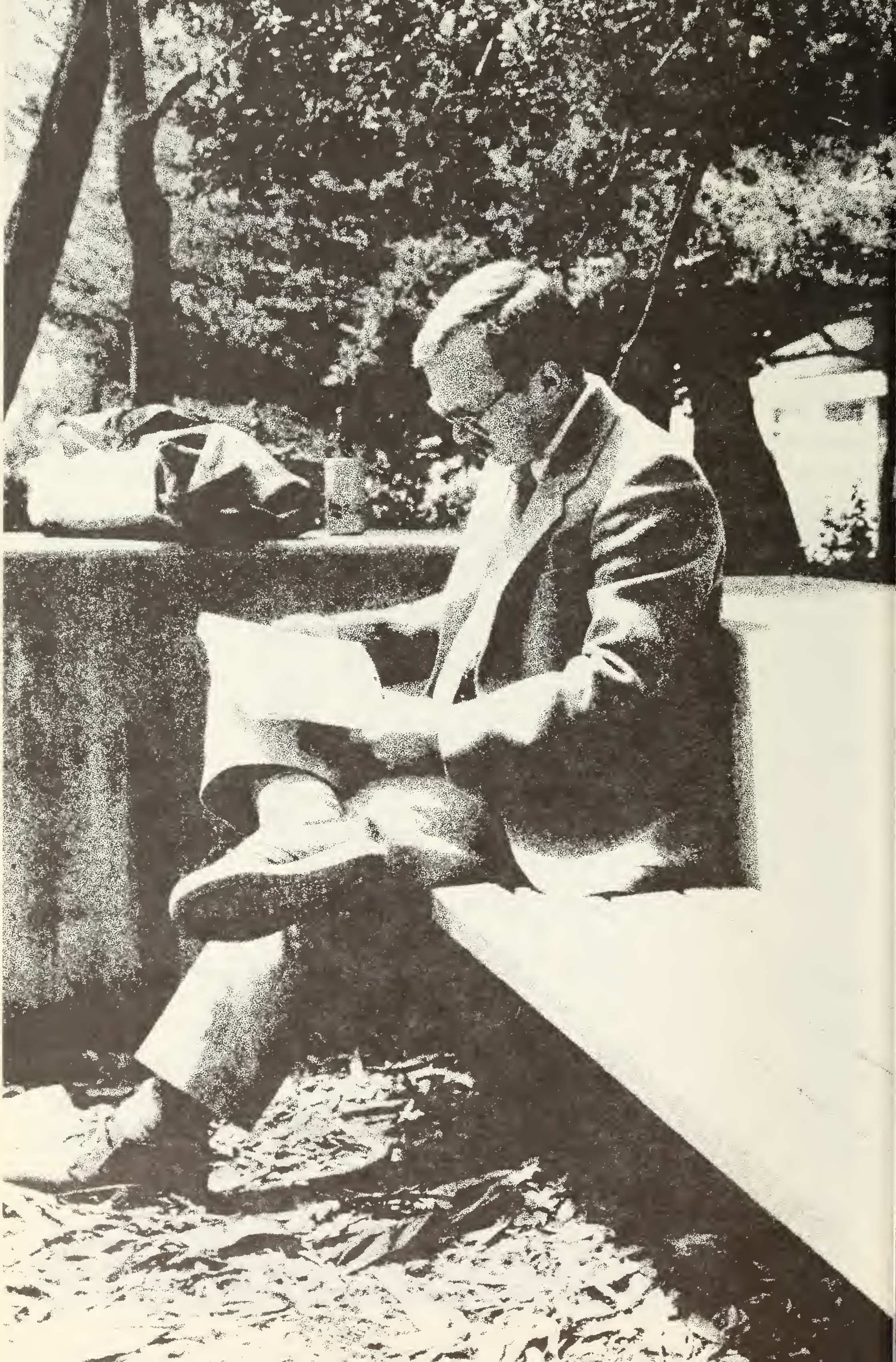
Michael R. Merickel, Commander, U.S. Navy; Manager Civilian Institutions Program; B.S., United States Naval Academy, 1967; M.S. in Operations Analysis, Naval Postgraduate School, 1973.

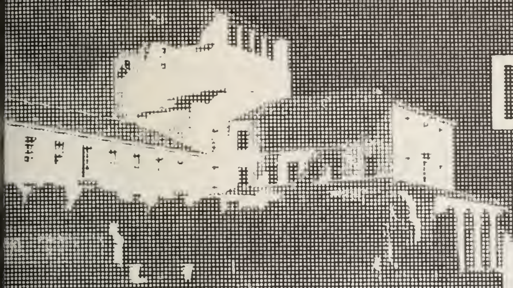
"The Navy's fully-funded graduate education program supports 79 subspecialties. This involves 65 curricula, 40 at NPS and 25 at over 50 civilian institutions. Programs offered at NPS are not available at civilian institutions. Approximately 20% of the fiscal year officer graduate education assignments are slated for these universities. Where more than one school is listed for a particular curriculum, subspecialty education placement officers plan quota distribution.

Curriculum	Number	Length	Institution	Primary Consultant
Chemistry	382	2 yrs.	Various	NAVSEASYSCOM
Criminal Law	884	1 yr.	Various	JAG
Education and Training Management	867	12-18 mos	Various	CNET
Environmental Law	880	1 yr.	George Washington Univ	JAG
Facilities Engineering	47X	1-2 yrs.	Various	NAVFACENGCOM
Forensic Science and Law	885	1 yr.	George Washington Univ.	JAG
International Law	887	1 yr.	Various	JAG
Joint Intelligence	990	9-12 mos.	Defense Intell. Sch.*	NAVINTCOM
Labor Law	886	1 yr.	Various	JAG
Advanced Military Justice	881	9-12 mos.	JAG School	JAG
Logistics Management	700	15 mos.	Air Force Inst. of Technology*	CHNAVMAT
Naval Const. & Engrg.	510	2-3 yrs.	M.I.T.	NAVSEASYSCOM
Nuclear Physics (Weapons & Effects)	521	18 mos.	Air Force Inst. of Technology*	CNO-OP98IN DEFNUCAGCY
Nuclear Engineering (ED)	520	18-24 mos.	Penn State Univ	NAVSEASYSCOM
Ocean Engineering	472	1-2 yrs.	Various	NAVFACENGCOM
Ocean Law	883	1 yr.	Various	JAG
Petroleum Management	811	17 mos.	U. of Kansas	NAVSUPSYSCOM
Petroleum Engineering	630	12-24 mos.	Various	NAVFACENGCOM
National Security Affairs (Western Hemisphere)	685	2 yrs.	Various	CNO-OP06 DEFNUCAGCY
Public Affairs	920	1 yr.	Various	CHINFO
Religion	97X	9 mos.	Various	CHCHAP
Retailing	830	1 yr.	Various	NAVSUPSYSCOM
Subsistence Technology	860	15-21 mos.	Michigan St.*	NAVSUPSYSCOM
Supply Aquis/Distrib Mgmt	810	12-18 mos.	Various	NAVSUPSYSCOM
Tax Law	882	1 yr.	Various	JAG

**No NROTC Unit at Institution*

Inquiries concerning curricula conducted at other universities should be directed to Manager, Civilian Institutions Program, Naval Postgraduate School, Monterey, CA 93943. Telephone (408) 646-2319 or autovon 878-2319.





ACADEMIC DEPARTMENTS AND COURSE DESCRIPTIONS

The faculty of the Naval Postgraduate School performs its graduate-education functions through eleven academic departments and three interdisciplinary academic groups, each headed by a designated chairman. The departmental affiliations of the faculty members, the course offerings, and the courses of study are contained in the individual department descriptions which follow.

In support of the courses of study, an active research program is carried on by the faculty and students. The research projects are supported by the Office of Naval Research, the Director of Naval Laboratories, the various Naval Systems Commands, and the National Science Foundation, as well as by other agencies and organizations. The ongoing projects cover a broad spectrum of research problems and include both theoretical and experimental investigations.

The faculty maintains close liaison with programs at Department of Defense research laboratories and development centers, and the knowledge acquired and maintained through this association is incorporated throughout the instructional program. Faculty members are formally cleared for classified matter, and storage and control facilities are available for all levels of security classification. This allows both students and faculty full access to classified material as needed.

The undergraduate-level courses included in the departmental offerings are taken by students, as required, to prepare them for the graduate-level program. Much of this preparatory subject matter is available for off-campus self-study through the School's Continuing Education Program.

In the course listings that follow, the first two letters in the course designator refer to the department in which it is taught. The following table lists the course alpha prefix codes by department:

Administrative Sciences	
Service Courses	AS
Telecommunications Systems Management	CM
Defense Communications	CO
Information Systems	IS
Management	MN
Aeronautics	AE
Antisubmarine Warfare	ST

Aviation Safety	AO
Command, Control And Communications	CC
Computer Science	CS
Electrical and Computer Engineering	EC
Electronic Warfare	EW
Mathematics	MA
Mechanical Engineering	ME
Materials Science	MS
Meteorology	MR
National Security Affairs	NS
Oceanography	
Oceanography Sciences	OC
Hydrographic Sciences	GH
Operations Research	
Operations Analysis	OA
Service Courses	OS
Physics	PH
Chemistry	CH
Science And Engineering	SE

The courses are assigned course numbers in accordance with their levels of academic credit as follows:

0001-0999	No credit
1000-1999	Lower division credit
2000-2999	Upper division credit
3000-3999	Upper division or graduate credit
4000-4999	Graduate credit

The two numbers in parenthesis (separated by a hyphen) following the course title indicate the hours of instruction per week in classroom and laboratory respectively. Laboratory hours are assigned half the value shown in calculating quarter hours for the credit value of the course. Thus a (3-2) course (having three hours recitation and two hours laboratory) will be assigned credit value of 4 quarter hours.

DEPARTMENT OF ADMINISTRATIVE SCIENCES

Willis Roswell Greer, Jr., Professor of Accounting and Chairman (1982);* B.S., Cornell Univ., 1961; M.B.A., 1966; Ph.D., Univ. of Michigan, 1971; C.M.A., 1976.

Shahid Latif Ansari, Adjunct Professor of Accounting (1983); B.Com., University of Karachi, 1965; M.B.A., 1967; Ph.D., Columbia University, 1973.

Louis A. Armijo, Adjunct Research Professor of Administrative Sciences (1984); B.S., Univ. of Texas, 1976; Ph.D., Cornell Univ., 1980.

Dan Calvin Boger, Associate Professor of Economics (1979); B.S., Univ. of Rochester, 1968; M.S., Naval Postgraduate School, 1969, M.A., Univ. of California at Berkeley, 1977; Ph.D., 1979.

Bruce Bloxom, Adjunct Research Professor of Psychology (1983); B.A., Yale Univ., 1961; M.S., Univ. of Washington, 1962; Ph.D., 1966.

Tung Xuan Bui, Assistant Professor of Management Information Systems (1984); M.A., Univ. of Fribourg, 1974; M.Phil., New York Univ., 1984; Ph.D., Univ. of Fribourg, 1980; Ph.D., New York Univ., 1985; A.P.C., Univ. of Lausanne, 1978; A.P.C., Univ. of Geneva, 1980; A.P.C., Univ. of Fribourg, 1981.

Philip Bromiley, Assistant Professor of Financial Management (1981); B.A., The Johns Hopkins Univ., 1974; Ph.D., Carnegie-Mellon Univ., 1982.

Paul Marshall Carrick, Associate Professor of Management (1969); B.A., Northwestern Univ., 1949; Ph.D., Univ. of California at Berkeley, 1956.

John Wallis Creighton, Professor of Management (1967); B.S., Univ. of Michigan, 1938; B.A., Hastings College, 1939; Ph.D., Univ. of Michigan, 1954.

Leslie Darbyshire, Professor of Financial and Strategic Management (1961); B.A., Univ. of Bristol, 1950; D.B.A., Univ. of Washington, 1957.

Daniel Roy Dolk, Assistant Professor of Management Information Systems (1982); B.S., Rensselaer Polytechnic Institute, 1966; M.S., 1967; M.S., Univ. of Arizona, 1977; Ph.D., 1982.

Mark Jan Eitelberg, Adjunct Research Professor of Public Administration (1982); A.B., Franklin and Marshall College, 1970; M.P.A., New York University, 1973; Ph.D., 1979.

Richard Sanford Elster, Professor of Management and Psychology (1969); B.A., Univ. of Minnesota, 1963; M.A., 1965; Ph.D., 1967. (Presently Deputy Assistant Secretary of the Navy for Manpower.)

Lloyd B. Embry, Adjunct Professor of Administrative Sciences (1985); B.S., U.S. Naval Academy, 1967; M.B.A., Harvard Univ., 1974; Ph.D., Rand Graduate Institute, 1984.

Carson Kan Eoyang, Associate Professor of Management (1974); B.A., Massachusetts Institute of Technology, 1966; M.B.A., Harvard Univ., 1968; Ph.D., Stanford Univ., 1976.

Kenneth James Euske, Associate Professor of Accounting (1978); A.B., Gonzaga Univ., 1967; M.B.A., Dartmouth College, 1969; D.B.A., Arizona State Univ., 1978.

Roger Dennis Evered, Associate Professor of Administrative Sciences (1979); B.S., Univ. of London, 1953; M.S., Univ. of California at Los Angeles, 1972; Ph.D., 1973.

James Morgan Fremgen, Professor of Accounting and Associate Chairman for Instruction (1965); B.S.C., Univ. of Notre Dame, 1954; M.B.A., Indiana Univ., 1955; D.B.A., 1961; C.P.A., Indiana, 1964.

Barry Albert Frew, Lieutenant, S.C., U.S. Navy; Instructor in Information Systems (1984); B.S., Miami Univ., 1976; M.S. Naval Postgraduate School, 1984.

Leon Bernard Garden, Adjunct Professor of Administrative Sciences (1981); B.S., Univ. of California at Los Angeles, 1959; M.S., Naval Postgraduate School, 1972.

John Ridgely Goral, Adjunct Research Professor of Psychology (1983); B.S., Purdue University, 1969; M.A., The Ohio State University, 1970; Ph.D., 1972.

Ernest Vernon Haag, Captain, U.S. Navy; Instructor in Organizational Behavior (1984); B.S., University of California at Los Angeles, 1958; M.S., University of Southern California, 1980.

Reuben Travis Harris, Associate Professor of Organizational Behavior and Management (1978); B.S., Antioch College, 1969; M.B.A., Univ. of Rochester, 1972; Ph.D., Stanford Univ., 1975.

David Richard Henderson, Adjunct Research Professor of Economics (1984); B.Sc., Univ. of Winnipeg, 1970; M.A., Univ. of California at Los Angeles, 1974; Ph.D., 1976.

Paul Jerome Hoffman, Adjunct Research Professor of Administrative Sciences (1982); B.A., Stanford University, 1949; M.A., 1951; Ph.D., 1953.

Fenn Clark Horton, Associate Professor of Economics (1964); B.A., State Univ. of Iowa, 1950; M.A., Claremont Graduate School, 1967; Ph.D., 1968.

Carl Russell Jones, Professor of Information and Telecommunications Systems (1965); B.S., Carnegie Institute of Technology, 1956; M.B.A., Univ. of Southern California, 1963; Ph.D., Claremont Graduate School, 1965.

Kathleen Rothar Knott, Adjunct Research Instructor in Administrative Sciences (1984); B.A., Buffalo State College Univ., 1978; M.A., San Jose State Univ., 1984.

Natalie A. Koffman, Adjunct Research Instructor in Administrative Sciences (1985); B.S., Northwestern Univ., 1967; M.A., San Diego State Univ., 1983.

David Vincent Lamm, Commander, S.C., U.S. Navy; Assistant Professor of Administrative Sciences (1978); B.A., Univ. of Minnesota, 1964; M.B.A., The George Washington Univ., 1972; D.B.A., 1976.

Jack William LaPatra, Adjunct Professor of Systems Analysis (1983); B.S.E.E., Clarkson College, 1955; M.S., University of Iowa, 1956; Ph.D., 1963.

Mark Howard Lepick, Lieutenant Commander, U.S. Navy; Instructor in Manpower Personnel and Training Analysis (1984); B.S., U.S. Naval Academy, 1971; M.S., Naval Postgraduate School, 1982.

Shu Sheng Liao, Professor of Accounting, and Associate Chairman for Research (1977); B.A., National Taiwan Univ., 1965; M.S. Utah State Univ., 1968; Ph.D., Univ. of Illinois, 1971.

Norman Robert Lyons, Associate Professor of Management Information Systems (1979); B.S., Stanford Univ., 1966; M.S.I.A., Carnegie-Mellon Univ., 1970; Ph.D., 1972.

Jerry Lee McCaffery, Professor of Public Budgeting (1984); B.S., Univ. of Wisconsin, 1959; M.A., 1969; Ph.D., 1972.

John Franklin McClain III, Commander, S.C., U.S. Navy, Instructor in Acquisition and Contract Management (1985); B.S., Univ. of California at Berkeley, 1967; M.S., Naval Postgraduate School, 1977.

Richard Allin McGonigal, Associate Professor of Management (1974); B.S., Cornell Univ., 1951; B.D., Union Theological Seminary, 1954; S.T.M., Columbia Univ., 1966; Ph.D., Michigan State Univ., 1971.

Alan Wayne McMasters, Associate Professor of Operations Research and Administrative Sciences (1965); B.S., Univ. of California at Berkeley, 1957; M.S., 1962; Ph.D., 1966.

Stephen Louis Mehay, Assosciate Professor of Labor Economics (1985); A.B., Indiana Univ., 1965; M.A., Univ. of Illinois, 1967; Ph.D., Univ. of California at Los Angeles, 1973.

David Edwards Melchar, Lieutenant Colonel, U.S. Marine Corps; Instructor in Financial Management (1984); B.S., Roger Williams College, 1976; M.S., Naval Postgraduate School, 1980.

Nancy Ann Nieboer, Adjunct Research Professor of Psychology (1982); A.B., Hope College, 1964; M.Ed., Springfield College, 1969; Ph.D., United States International University, San Diego, 1975.

Clair Alton Peterson, Associate Professor of Economics (1962); B.B.A., Univ. of Minnesota, 1951; Ph.D., Massachusetts Institute of Technology, 1961.

Kent Roberson, Adjunct Research Instructor in Administrative Sciences (1985); B.S., Univ. of Tulsa, 1976; M.A., 1978.

Nancy Charlotte Roberts, Associate Professor of Organizational Behavior (1986); Diplome Annuel, La Sorboone, 1966; B.A., Univ. of Illinois, 1967; M.A., 1968; Ph.D., Stanford Univ., 1983.

Joseph Girard San Miguel, Professor of Accounting (1982); B.B.A., University of Texas, 1967; M.B.A., North Texas State University, 1968; Ph.D., University of Texas, 1972; C.P.A., Texas, 1969.

Norman Floyd Schneidewind, Professor of Computer Science (1971); B.S.E.E., University of California at Berkeley, 1951; M.S.C.S., San Jose State University, 1983; M.B.A., University of Southern California, 1960; M.S.O.R. (ENGR), 1970; D.B.A., 1966; C.D.P., 1976.

Taracad R. Sivasankaran, Assistant Professor of Management Information Systems (1985); B.S., Calicut Univ., 1972; M.B.A., Atlanta Univ., 1980; Ph.D., New York Univ., 1984.

Raymond William Smith, Lieutenant Commander, S.C., U.S. Navy; Instructor in Acquisition and Contract Management (1985); B.S., Utah State Univ., 1970; M.S., Naval Postgraduate School, 1982.

Loren Michael Solnick, Associate Professor of Labor Economics (1985); B.A., City College of New York, 1968; M.S., Cornell Univ., 1970; Ph.D., 1973.

Michael P. Spencer, Adjunct Professor of Administrative Sciences (1983); A.B., Univ. of California, 1964; M.B.A., Univ. of Santa Clara, 1974; J.D., 1978.

Thomas Gayle Sticht, Adjunct Research Professor of Industrial Psychology (1983); B.A., University of Arizona, 1962; M.A., 1964; Ph.D., 1965.

James Edward Suchan, Associate Professor of Management Communication (1985); B.A., State University of New York at Buffalo, 1971; M.A., 1973; Ph.D., University of Illinois, 1980.

Thomas George Swenson, Assistant Professor of Management (1982); B.A., Wichita State Univ., 1972; M.S., 1974; Ph.D., Univ. of Oregon, 1982.

William Romans Talutis, Lieutenant Commander, U.S. Navy; Instructor in Contract Management (1981); B.S., Texas A&M Univ., 1964; M.S., Naval Postgraduate School, 1976.

George William Thomas, Associate Professor of Economics (1978); B.S., Southern Illinois Univ., 1967; M.S., Purdue Univ., 1969; Ph.D., 1971.

Ronald Alfred Weitzman, Associate Professor of Psychology (1971); B.A., Stanford Univ., 1952; M.A., 1954; Ph.D., Princeton Univ., 1959.

David Richard Whipple, Jr., Professor of Economics and Policy Analysis and Associate Chairman for Systems and Programs (1971); B.A., Univ. of St. Thomas, 1964; M.A., St. Mary's Univ., 1966; Ph.D., Univ. of Kansas, 1971.

Dona Carol Zimmerman, Adjunct Research Instructor in Administrative Science (1983); B.A. Metropolitan State College, 1979; M.S., The Pennsylvania State University, 1982.

Ray Alan Zimmerman, Adjunct Research Professor of Psychology 1984); B.A., Metropolitan State College of Denver, 1979; M.S., Pennsylvania State Univ., 1981; Ph.D., 1983.

Emeritus Faculty

William Howard Church, Professor Emeritus (1956); B.A., Whittier College, 1933; M.S.P.A., Univ. of Southern California, 1941.

Melvin Bernard Kline, Professor Emeritus (1970); B.S., College of the City of New York, 1941; M.S., Stevens Institute of Technology, 1952; M.E., Univ. of California at Los Angeles, 1959; Ph.D., 1966.

John David Senger, Professor Emeritus (1957); B.S., Univ. of Illinois, 1945; M.S., 1948; Ph.D., 1965.

Chester Arthur Wright, Assistant Professor Emeritus (1973); B.A., San Francisco State Univ., 1965; M.S., Univ. of California at Los Angeles, 1968.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES

Programs leading to degrees must be arranged in consultation with the Chairman, Department of Administrative Sciences.

MASTER OF SCIENCE IN INFORMATION SYSTEMS

1. A candidate for the degree Master of Science in Information Systems must successfully complete or validate core courses in each of the following disciplines:

   Accounting and Financial Management
   Organizational Sciences
   Information Systems
   Computer Science
   Economics
   Management Theory and Practice
   Quantitative Methods

2. In addition, the candiate must successfully complete 48 quarter hours of graduate-level course work and an acceptable thesis or project. At least 12 quarter hours of the course work must be at the 4000-level. Further, this graduate-level course work must include at least 24 quarter hours in the administrative sciences and at least 16 quarter hours in computer science.

3. The candidate's program must be approved by the chairperson of the Department of Administrative Sciences.

MASTER OF SCIENCE IN TELECOMMUNICATIONS SYSTEMS MANAGEMENT

The degree of Master of Science in Telecommunications Systems Management will be awarded at the completion of an interdisciplinary program that satisfies the following requirements:

1. A minimum of 56 quarter hours of graduate-level work of which at least 12 quarter hours must represent courses at the 4000 level.

2. The program must consist of a minimum of graduate-level credit as follows:

Administrative Sciences and Quantitative Methods	40
Communications Systems and Computer Science	16

3. In addition to the 56 quarter hours of graduate-level course credit, an acceptable thesis shall have an advisor and a second reader, at least one of whom must be from the Department of Administrative Sciences.

MASTER OF SCIENCE IN MANAGEMENT

The degree Master of Science in Management requires:

1. Completion or validation of the Management Fundamentals program, which consists of a total of 32 quarter hours of 2000 and 3000 level courses, including a minimum of the following hours by disciplines:

Accounting and financial management	6
Economics	6
Organization and management	6
Quantitative methods	8

2. In addition to the above, completion of a minimum of 48 hours of graduate level courses, at least 12 hours of which are at the 4000 level.

3. Completion of an approved sequence of courses in the student's area of concentration.

4. The submission of an acceptable thesis on a topic previously approved by the Department of Administrative Sciences.

5. Final approval of a program from the Chairperson, Department of Administrative Sciences.

DEPARTMENTAL COURSE OFFERINGS

SERVICE COURSES

AS 1501 English Language Skills (0-4).
A lower division course in basic English to increase speaking and writing skills and increase comprehension. A pre and post conversation test will be administered to each student. *Open only to Allied Officers.*

Upper Division or Graduate Courses

AS 3501 Project Management (4-2).
This course provides the student with an understanding of the underlying philosophies and concepts of the systems acquisition process and the practical application of project management methodologies within this process. Topics include the evolution and current state of systems acquisition management; the fiscal cycle and PPBS; the defense systems acquisition cycle; user-producer acquisition management disciplines and activities; and project planning, organization, staffing, directing, and controlling. The course includes participation in Defense Management Simulation, a system life cycle, computer-based simulation laboratory exercise. *(Open only to students not enrolled in Administrative Sciences, Telecommunication Systems Management, or Information Systems Management curricula.)*

AS 3610 Economic Analysis and Operations Research (4-0).
A presentation of basic economic concepts involved in the decision processes of individuals and groups faced with scarcity of resources. Topics covered include consumer theory and demand, individual behavior under uncertainty, producer theory and supply, firm behavior under uncertainty, output and input market structures, partial and general equilibrium analysis, and market imperfections and welfare analysis. PREREQUISITES: MA 2042, MA 2110 (concurrently), OA 3201 (concurrently).

AS 3611 Planning and Capital Allocation in the Department of Defense (4-1).
Extension of concepts discussed in AS 3609 to allocation of resources over time. Covered are models of consumption and production overtime, optimal investment decision rules and investment under uncertainty. Models of welfare economics and cost-benefit analysis are presented. Also covered are planning and decentralization techniques using decomposition algorithms. Cost effectiveness and costing models from current practices in DoD are examined. Institutional procedures and processes such as PPBS, budget enactment and apportionment, FYDP, systems acquisition/DSARC and ZBB are also discussed. PREREQUISITES: AS 3610, OA 3103.

Graduate Course

AS 4613 Theory of Systems Analysis (4-0).
Systems analysis (cost-effectiveness analysis) formulated as commensurable and incommensurable physical capital investment choice models. Emphasis on decision rules and the nature of opportunity costs with respect to scale and timing of investment. Interpretation of methods of risk, modeling and solution computation. Theory of the second best; theory of the social discount rate. Introduction to models of planning and control emphasizing decentralization of the decision-making problem. PREREQUISITES: AS 3611, OA 4201 (concurrently).

TELECOMMUNICATIONS SYSTEMS MANAGEMENT

CM 0001 Seminar for Telecommunications Management Students (0-2).
Guest lecturers, thesis and research presentations.

CM 0810 Thesis Research for Telecommunications Management Students (0-0).
Every student conducting thesis research will enroll in this course.

Upper Division or Graduate Courses

CM 3001 Economic Evaluation of Telecommunications Systems I (4-0).
Study of economic evaluation concepts and methods for planning, coordinating and controlling telecommunications systems. Topics include cost performance (value) analyses, capacity planning, pricing of telecommunications services, and make, lease, buy decisions. PREREQUISITE: MN 2155.

CM 3002 Economic Evaluation of Telecommunications Systems II (4-0).
Continuation of CM 3001. PREREQUISITE: CM 3001.

CM 3111 C3 Mission and Organization (4-0).
A survey of command, control and communications organizations within OSD, JCS and the Service Headquarters. Execution of National Strategic Nuclear Policy and planning for joint employment of general purpose forces are discussed. Service combat organization and service tactical C3 systems are covered. Emphasis is on description of existing C3 organizations and systems with brief historical perspective. PREREQUISITE: SECRET clearance.

CM 3112 Navy Telecommunications Systems (4-0).
Description of the Naval Telecommunications System (NTS) with emphasis on the organization and management control and operational direction of the facilities. Current subsystems are described in detail. PREREQUISITES: SECRET clearance and CM 3111 or consent of the instructor.

Graduate Courses

CM 4003 Seminar in Telecommunications Systems Management (1-0 to 4-0).
Study of a variety of topics of current interest in telecommunications systems, to be determined by the instructor. PREREQUISITES: A background in telecommunications systems and permission of the instructor.

CM 4502 Telecommunication Networks.
This course covers telecommunication network design, development, and management topics, including service requirements determination, signaling, interspersability, switching, synchronization, protocols, demand, and architecture. A variety of applications will be presented. PREREQUISITE: IS 3502.

CM 4925 Telecommunications: Systems, Industry, Regulation (4-0).
Study of the telecommunications industry (domestic and international) and its regulation (Congress and Executive Branch, Federal Communications Commission, International Telecommunications Union). Considerations of special issues: allocation of the spectrum, telecommunication service pricing and DOD lease decisions. PREREQUISITES: CM 3002, OS 3005.

INFORMATION SYSTEMS

IS 0001 Seminar for Computer Systems Management Students (0-2).
Guest Lecturers. Thesis and research presentations.

IS 0810 Thesis Research for Computer Systems Management Students (0-0).
Every student conducting thesis research will enroll in this course.

Upper Division Course

IS 2000 Introduction to Computer Management (3-0).
This course will provide an introduction to the field of automatic data processing and the functions and responsibilities of the computer manager. Specific topics are: survey of comtemporary computer applications, hardware and software: functions and responsibilities of the computer manager; introduction to the role of personnel management, financial management, quantitative methods and computer science in computer management.

IS 2100 Information Systems Laboratory (0-2).
The objective is to develop computer literacy early in the Computer Systems student's program and to reinforce lecture material in IS 2000. Students will perform elementary laboratory assignments involving use of microcomputer systems and digital logic; hardware architecture; machine, assembly and high-order language programming; and application packages such as database management and word processing. PRERE—QUISITE: IS 2000.

Upper Division or Graduate Courses

IS 3000 Distributed Computer Systems (4-0).
This course covers the technology, application and management of distributed computer systems. Specific topics include distributed processing, distributed data base management, communication facilities and protocols, economic and performance analysis, and managerial and organizational problems. PREREQUISITES: CS 2810, (CS 3010 or CS 3400) and IS 3170 (concurrently).

IS 3100 Survey of Contemporary Computer Systems (3-0).
Study and analysis of contemporary large, mini and micro computer systems, including hardware, applications of software, operating systems and price characteristics. Emphasis is on the study and comparison of specific vendor systems which are available in the marketplace and evaluation of their applicability to various military requirements. Trends in computer technology and pricing structures. PREREQUISITES: CS 2810, (CS 3010 or CS 3400), (CS 3030 or CS 3112) and IS 3170).

IS 3170 Economic Evaluation of Information Systems I (4-0).
The study of economic evaluation concepts and methods for planning, coordinating and controlling computer based information systems design, implementation and analysis. Topics included are cost performance (value) analysis, capacity planning, capital budgeting techniques, capital budgeting systems, budgeting and pricing for computer services, information resource management and a study of the Information Industries (computers, software and telecommunications). PREREQUISITE: MN 2155.

IS 3171 Economic Evaluation of Information Systems II (4-0).
A continuation of IS 3170. PREREQUISITE: IS 3170.

IS 3183 Management Information Systems (4-0).
Study of what an information system is, how the computer and other resources fit into the system, and management considerations involved in computer-based and other information systems. Study of computer and MIS concepts. PREREQUISITES: MN 3105 and a course in computers.

IS 3220 Computer Center Management (3-2).
Theory and practice of the management of computer center operations. Specific topics include facilities planning, production scheduling and control, operational procedures, and computer performance evaluation. PREREQUISITES: CS 3030, and OS 3004 or equivalent.

IS 3502 Computer Networks: Wide Area/Local Area (4-0).
Analysis, evaluation, management, and development of wide area and local area computer networks and supporting packet switching computer communication systems. Specific topics include network architectures, protocols, functions, standards, error detection/correction, cost reduction, interconnection, management, and security. Example systems include Defense Data Network, System Network Architecture, DECNET, Ethernet, token ring, broadband, fiber optics, private automatic branch exchanges, and satellite communications systems. PREREQUISITES: CS 2810, CS 3010, and OS 3004.

Graduate Courses

IS 4133 Software Cost Estimation (4-0).
Study of alternative methods of estimating software costs throughout the life cycle. A project is used to provide a practical experience. PREREQUISITE: IS 3171.

IS 4182 Information Systems Management (4-0).
Management of the ADP in the Federal Government, especially in the Department of Defense. Specific topics covered include: Computer Center and Computer System development management; procurement of computer systems; installation and effective utilization of ADP systems. PREREQUISITE: IS 4200 (concurrently).

IS 4183 Applications of Database Management Systems (4-0).
Applications-oriented introduction to database management systems technology. Survey of current database systems and approaches to database technology. Technical and administrative considerations involved in a database implementation project are considered. Students will be expected to implement an applications system using a database management package. PREREQUISITES: CS 3010, CS 3020, IS 2000.

IS 4185 Decision Support Systems (4-0).
The application and design of computer-based information systems for management planning, control and operations. PREREQUISITES: MN 2155, MN 3105, OS 3101 and IS 2000, or equivalent.

IS 4200 System Analysis and Design (4-0).
This course covers computer-based system development including the concepts, methodologies and techniques of: information system requirements analysis, technical and economic feasibility studies, system costing, functional specifications, computer and data communication hardware and software trade-off evaluations and specifications, conversion and testing. PREREQUISITES: (CS 2810, CS 3010, and CS 3020) or (CS 2810, CS 3111, and CS 3400).

IS 4300 Software Engineering and Management (4-0).
The objective of this course is to educate the student in areas which are of great concern to the Department of Defense in the fields of software engineering and management. This will be accomplished by studying the wealth of material available in the literature and applying what has been learned by using the computer to analyze typical software. Written and oral technical and management reports would be made which document the student's findings. PREREQUISITES: OS 3004, CS 3030, IS 3171 or equivalent.

IS 4925 Seminar in Information Systems (1-0 to 4-0).
Study of a variety of topics of current interest in information systems, to be determined by the instructor. PREREQUISITES: A background in information systems and permission of the instructor.

MANAGEMENT

MN 0001 Seminar for Management Students (0-2).
Guest Lecturers. Thesis and research presentations.

MN 0810 Thesis Research for Management Students (0-0).
Every student conducting thesis research will enroll in this course.

Upper Division Courses

MN 2031 Economic Decision Making (4-0).
The macroeconomic section focuses on methods of national income determination, the consumption function, the multiplier, and the impact of fiscal and monetary policies. The microeconomic section analyzes individual economic decisions and their relation to attainment of market equilibria. PREREQUISITE: MA 2300 concurrently.

MN 2106 Fundamentals of Organizational Behavior (4-0).
Study of individual and group behavior in organizational contexts. Emphasis is on the implications of motivation, perception, communication, cohesion group dynamics, social influence and leadership on performance and satisfaction in formal organizations.

MN 2150 Financial Accounting (4-0).
Study of basic accounting concepts and standards. Specific topics include the accounting cycle, asset valuation, equities and capital structure, earnings measurement, cash-flow analysis, and financial-statement analysis. *(May be taken through Continuing Education.)*

MN 2155 Accounting for Management (4-0).
Brief introduction to financial accounting, with emphasis on the content and analysis of financial statements. Specific topics in management accounting include fundamentals of cost accounting, cost-volume analysis, budgeting, relevant costs for decision making, capital budgeting, and financial performance measures. (Closed to students who must take or have taken MN 2150 and MN 3161.)

MN 2302 Seminar for Acquisition and Contracting Students (0-3).
Guest lectures. Thesis and research presentations. Certified Professional Contracts Management (CPCM) certificate examinations. *Graded on Pass/Fail basis only.*

Upper Division or Graduate Courses

MN 3001 Organizational Research Methods (4-2).
This course focuses on the design and management of rigorous research and studies of complex organizational phenomena. It includes formulation of central questions and

hypotheses, assessing alternative methods of data collection (e.g., experiments, surveys, interviews, observation, etc.), sampling, statistical analysis and presentation of data, and threats to validity. PREREQUISITES: MN 3105 and OS 3106.

MN 3101 Personnel Management (4-0).
Study of the principles and practices of personnel administration in business and government organizations. A survey of the history, development, and current status of labor-management relations in industry and government. Analysis of the labor market and the implications of government regulations for wages and labor-management bargaining. PREREQUISITE: MN3105.

MN 3105 Organization and Management (4-0).
Study of managing organization in a dynamic environment. Emphasis is on managerial decision making, planning and control, organizational structure and planned organizational change and their systemic impacts on organizational effectiveness and adaptation. PREREQUISITE: MN 2106.

MN 3111 Personnel Management Processes (4-0).
A broad coverage of human behavior in the work situation with special emphasis on the problem of work in the Naval environment. Topical areas covered include selection, placement, training, and evaluation of personnel; motivation, remuneration, morale, supervision, and working conditions in organizations; equipment design and man-machine relationships; and consumer (user) behavior and the impact of technological programs. PREREQUISITES: MN 3105, OS 3106 (concurrently).

MN 3114 Organization Development I (4-2).
A comprehensive survey of theories and methods of planned organizational change. Topics include assumptions and values of organization development, consulting strategies, diagnostic techniques, intervention design, implementation, and evaluation. PREREQUISITE: MN 3105.

MN 3116 Organization Development Field Work (0-4).
A laboratory course to accompany Organization Development III — MN 4124. Emphasis is on becoming familiar with current issues and practices associated with the application of organization development in military organizations. Students are expected to be in the field 2 weeks. PREREQUISITES: MN 3114, MN 4123 and MN 4124 (concurrently). *Graded on Pass/Fail basis only.*

MN 3121 Leadership and Group Behavior (4-0).
The study of groups in different settings and factors affecting both individual and group behavior. Attention will be given to such concepts as authority, conformity, cohesiveness, effectiveness, and leadership. Emphasis will be placed on methods of observing group action.

MN 3123 Military Sociology (4-0).
An exploration of classical theories of sociology pertaining to civil-military relations with modern applications to command and control problems. Sexism, racism, family dissolution, unionization, bureaucratic inertia, career patterns and professionalism are considered from the perspective of sociology. PREREQUISITES: MN 3105.

MN 3140 Microeconomic Theory (4-0).
Determination of the allocation of resources and the composition of output. Consumer and Producer Choice Theory. Partial and general equilibrium analysis. Welfare economics. Applications to defense problems are emphasized. PREREQUISITES: MN 2031, MA 2300 or their equivalents.

MN 3161 Managerial Accounting (4-0).
Introduction to cost accounting, including overhead costing, job order and process systems, variable and absorption costing, and standard cost. Emphasis is on applications of accounting data to planning, control, and decision making. Topics covered include budgeting, flexible budgets, standard costs and variance analysis, performance measures, cost-volume-profit analysis, cost analysis for decision making, and capital budgeting. PREREQUISITE: MN 2150. *(May be taken through Continuing Education.)*

MN 3172 Public Policy Processes (4-0).
A presentation by which resources are allocated to the production of goods in the Defense sector. Defense budget preparation, Presidential policy-making and management, and Congressional budget action are considered and placed within the context of the theory of public goods. PREREQUISITES: MN 3140, MN 3105.

MN 3301 Introduction to Systems Acquisition and Project Management (4-0).
This course provides the student with an understanding of the underlying philosophies and concepts of the systems acquisition process and the practical application of project management methodologies within this process. Topics include the evolution and current state of systems acquisition management; the defense systems acquisition cycle; user-producer acquisition management disciplines and activities; and project planning, organization, staffing, directing, and controlling. PREREQUISITE: MN 3105 or equivalent. *Restricted to management students not enrolled in the Acquisition and Contracting curriculum.*

MN 3303 Principles of Acquisition and Contracting (4-0).
Introduction to the principles of acquisition and contracting. This course studies the fundamentals of the Defense Acquisition Regulation (DAR) and the Federal Acquisition Regulation (FAR); the acquisition and contracting processes including the determina- of need, acquisition strategies, basic contract law, ethics, and contracting methodologies; and acquisition/contracting management techniques. PREREQUISITES: Enrolment in the Acquisition and Contracting Management curriculum, MN 3105 or equivalent.

MN 3304 Contract Pricing and Negotiations (4-0).
This course involves the study of pricing theory and strategies, costing methodologies, cost and price analysis, cost principles, cost accounting standards, and contract negotiations. Students develop and sharpen negotiation skills by participating in practical negotiation exercises. PREREQUISITES: MN 3303, MN 3140, OS 3105.

MN 3305 Contract Administration (4-0).
This course stresses the management skills and techniques necessary for the successful administration of Government prime contracts and subcontracts. Topics include managing contract progress and performance, change control, quality control, cost/financial control, property, terminations, and regulatory and policy concerns. PREREQUISITE: MN 3304.

MN 3306 Telecommunications Systems Acquisition and Contract Management (4-0).
Study of the principles, concepts, and issues involved in the acquisition of telecommunications systems, components, and services. Topics include hardware acquisition, software acquisition, leasing of services, DON/DCA acquisition and contracting interactions and project management. PREREQUISITES: CM 3002 and MN 3105.

MN 3307 A.D.P. Acquisition (4-0).
Introduction to the management principles, concepts and issues involved in Federal Government acquisition of ADP requirements. The course focuses on the concepts of system acquisition project management as they pertain to ADP Acquisition and specific buying of both computer hardware and software and administration issues through case study analysis. PREREQUISITE: Computer Systems student, or permission of Instructor.

MN 3308 Introductions to Systems Engineering (4-0).
This course provides the student with an introduction to system design and development, the underlying philosophy, concepts, and methodology of systems engineering, and its application in the Department of Defense and the Navy. It establishes the foundation for later courses in reliability, maintainability, and logistics. Topics covered include systems engineering overview, the system life cycle and system design process, decision analysis, and the systems engineering disciplines. Emphasis is placed on the planning and design phases of the system life cycle. PREREQUISITE: A course in statistics.

MN 3309 Maintainability Engineering (3-0).
The maintainability program plan (MIL-STD-470). Maintenance engineering analysis. Developing the maintenance concept. Concepts of system effectiveness — reliability, maintainability, availability, dependability, and capability. Maintainability statistics, prediction, demonstration, and evaluation (MIL-STD-471). Maintainability design requirements and trade-off analysis. Maintainability program management, design reviews, data collection. Case studies and examples. PREREQUISITE: MN 3308 or a course in statistics.

MN 3310 Manpower Planning and Development (4-0).
Examines procedures and principles for establishing positions and acquiring and administering personnel and training requirements for new systems and major modifications. PREREQUISITE: MN 3105.

MN 3311 Acquisition Management Simulation (0-4).
This course is a system life cycle, computer-based simulation, interactive laboratory exercise in which the students, in teams, plan, organize, and manage the development and production of a missile system. Trade-offs among performance, reliability, cost, and schedule, evaluation of technical proposals, contract and incentive negotiations, and DSARC reviews are included. PREREQUISITE: MN 3301 or MN 3307 (may be taken concurrently). *Graded on Pass/Fail basis only.*

MN 3333 Managerial Communication Skills (4-0).
Study of communicating as an integral function of management. A competency-oriented course designed to enable students to develop proficiency in those aspects of speaking, listening, writing, and reading that are particularly relevant to management. Considers various facets of human communication in 2-person, small group, audience-sized and organization-wide situations. Topics include subordinate-superior interactions, conducting meetings, making presentations, writing point papers, resolving conflicts, and telecommunicating.

MN 3371 Contracts Management and Administration (4-0).
Study of the characteristics/phases of the contracting process. Coverage includes planning, execution and control of the contracting process; techniques used in purchasing goods and services of varying complexities; and the relationship of contracting to the acquisition process.

MN 3372 Material Logistics (4-0).
An overview of the elements of business logistics, including purchasing, inventory management, warehousing, materials handling, transportation and traffic management, facilities location, and the structure of the logistics function within an organization. PREREQUISITE: OS 3105.

MN 3373 Transportation Management I (4-0).
Analysis of transportation systems from a managerial perspective. Topics include carriers and users of systems; alternative modes; intra- and intermodal competitive relationships; regulatory and legal considerations; demand, cost, and pricing analysis; and managerial resource allocation problems. Application of these topics to the U.S. domestic freight transportation network. PREREQUISITE: MN 3140 (may be taken concurrently).

MN 3374 Production Management (4-0)
This course examines the production process. Emphasis is distributed among the technical, managerial, and defense aspects of production. Topic coverage ranges from production planning through production control. PREREQUISITES: MN 3105, and OS 3006.

MN 3375 Material Handling Systems Design (4-0).
A study of the principles and systems concepts of materials handling and their application in the design of a materials handling system. An overview of current DOD automated materials handling systems is also provided.

MN 3377 Inventory Management (4-0).
The inventory management process of the Naval Supply Systems Command, with emphasis on the procedures for determining when and how much of a given item to order. Provisioning, wholesale and retail replenishment, and the supply budgetary process. A required course for all Supply Corps officers in Administrative Science curricula, except Systems Inventory Management. PREREQUISITES: MA 2300 and OS 3105.

MN 3650 Health Economics (4-0).
An overview and analysis of the underlying elements of the continuing problems in the military and civilian health care delivery sectors. Elements covered are: organizational structure and change in the mode of delivery of health care; supply, demand and output and quality measurement of health services; the impact of health care legislation; the relationship of the military and civilian sectors. PREREQUISITE: Microeconomics, e.g. MN 3140, AS 3610 or equivalent.

MN 3760 Manpower Economics I (4-0).
An introduction to the theoretical aspects of labor economics. Concepts covered include the supply of labor, the demand for labor, market wage determination, internal labor markets, human capital formation, migration and mobility, compensating wage differentials, earnings equations, pay and employment discrimination, and unemployment and inflation. PREREQUISITE: MN 3140, AS 3610, or equivalent.

MN 3801 Seminar in Technology Transfer (4-0).
The study of dissemination and utilization of technology and associated problems with emphasis on communications, sociology, and organizational factors. PREREQUISITE: MN 3105 or graduate standing in a technical curriculum with consent of Instructor.

MN 3900 Selected Topics in Administrative Science (1-0 to 4-0).
An individualized program of study and readings in some area of administrative science, designed to meet the student's special educational needs. PREREQUISITES: A background in the area of study and departmental approval. *Graded on Pass/Fail basis only.*

Graduate Courses

MN 4105 Management Policy (4-0).
Study and analysis of complex managerial situations requiring comprehensive integrated decision making. Topics include operational and strategic planning, policy formulation, executive control, environmental adaptation, and management of change. Case studies in both the public and private sectors. PREREQUISITE: Open only to students in their final quarter of a Management Masters program.

MN 4106 Manpower Personnel Policy Analysis (4-0).
Study and analysis of manpower/personnel policy alternatives with emphasis on identifying the trade-offs involved, the dynamic impact of major policy decisions, and the short-term and long-term consequences of decisions. Review, use, and evaluation of tools to aid in selecting policy alternatives. Study of representative cases. PREREQUISITE: Open only to students in their final quarter of the Manpower-Personnel Analysis curriculum.

MN 4110 Multivariate Manpower Data Analysis (4-2).
Study of multivariate statistical methods for analyzing manpower problems. Emphasis is on use and interpretation of multiple regression and related techniques as applied to large personnel data sets. Skills in the use of computer packages such as SPSS and SAS, are developed. PREREQUISITE: OS 3106.

MN 4112 Personnel Testing and Selection (4-0).
Study of methods available for evaluating and predicting work performance in organizations. Use of employment interviewing, testing, life-history data, and rating scales for on-the-job behavior. Selection and placement decisions based on test validity and cost-benefit analysis. PREREQUISITE: MN 4110.

MN 4114 Personnel Performance Evaluation (4-0).
Current methods of appraising the performance of individuals in different types of work. Problems associated with each method. Performance evaluation as a system interfacing with selection, classification, training, advancement, and retention. PREREQUISITES: MN 3111 or OS 3106 and MN 3310.

MN 4116 Education and Training (4-2).
This course concentrates on adult learning theory, curriculum design, and instructional technology to help students teach, develop, and supervise curriculum and instruction. The course is especially oriented to the needs of the Organizational Development community. PREREQUISITE: MN 3105.

MN 4117 Job Analysis and Personnel Training (4-0).
Study of job analysis and its use in determining training requirements. Consideration of instructional systems development and training pipeline management. Attention to cost-benefit issues involving training in regard to selection, equipment design, changing job requirements, and career development. PREREQUISITE: MN 3111.

MN 4119 Seminar in Manpower Analysis (1-0 to 4-0).
Study of a variety of topics of current interest in manpower analysis, to be determined by the instructor. PREREQUISITES: A background in manpower analysis and permission of the instructor.

MN 4121 Organization Theory (4-0).
Study of the major theories of modern organizations. This course emphasizes the analysis of organizational phenomena from multiple perspectives using theories of individual, group, and organizational behavior. Topics include organization design and culture, political analysis of organizations, management of change, open systems theory, and contingency theories. PREREQUISITE: MN 3105.

MN 4122 Planning and Control: Measurement and Evaluation (4-0).
Theory and techniques of the managerial functions of planning and control. Emphasis will be placed upon the effects of the planning and control structure on the behavior of human components of the system. Topics will include the problems associated with the utilization of surrogates for measurement purposes; the analysis of the influence of assumptions, values, and objectives on the planning and control process; budgeting and forecasting; performance evaluation and reward structure. PREREQUISITES: MN 3105 and MN 3161.

MN 4123 Organization Development II (4-0).
A study of the field of organization development. The course provides knowledge and skills of organization development and consultative skills to improve organizational effectiveness. The course covers major theories of organization growth and development and a variety of OD strategies designed to improve organizational functions. Students will have opportunities to demonstrate and refine their individual skills in small group settings. PREREQUISITE: MN 3114.

MN 4124 Organization Development III (4-0).
Course provides an opportunity for students to practice organizational development with an actual client organization. Students will gain a thorough understanding of the complexities, strengths, and weaknesses of team O.D. consultation by integrating previously learned theory with practice. PREREQUISITES: MN 3114, MN 4123.

MN 4125 Managing Planned Change in Complex Organizations (4-0).
Examination of the approaches to planning and managing change efforts in complex social systems made up of the interdependent components: technology, structure, task and people, and of the role of the manager or staff specialist and the process of helping. Emphasis placed on strategies and technologies for diagnosis and planning aimed at effective implementation. Opportunities for practice using both simulations and actual organizational cases. Designed for graduate students interested in the problems involved in effective implementation of technologically, structurally, or human resource-based planned change efforts. PREREQUISITES: MN 3105 and Departmental permission.

MN 4126 Seminar in the Behavioral Sciences (1-0 to 4-0).
Study of a variety of topics of current interest in the behavioral sciences, to be determined by the instructor. PREREQUISITES: A background in the behavioral sciences and permission of the instructor.

MN 4127 Seminar in Organization Development (1-0 to 4-0).
Study of a variety of topics of current interest in organization development, to be determined by the instructor. PREREQUISITES: A background in organization development and permission of the instructor.

MN 4145 Policy Analysis (4-0).
The application of economic methods to nonmarket transactions. Analysis of large scale defense resource allocation problems. Weapon system definition. Life cycle cost models. Examples of cost-benefit and cost-effectiveness analyses. PREREQUISITES: MN 3161 and MN 3172.

MN 4151 Internal Control and Financial Auditing (4-0).
Study of the objectives and techniques of internal control systems and audits of financial records and reports. Specific topics include the independent audit function in America, audit evidence and procedures in general, the auditor's decision process, statistical sampling for auditing, and controls and audit problems in EDP systems. Audits of several transaction cycles are examined. PREREQUISITES: MN 3161, CS 2010, and OS 3106 or the equivalent.

MN 4152 Corporate Financial Management (4-0).
The management of the finance function in industry, with particular attention to defense contractors. Specific topics include cash and working capital management, long-term financing, and determination of optimal capital structure. PREREQUISITE: MN 3161.

MN 4153 Seminar in Financial Management (1-0 to 4-0).
Study of a variety of topics of current interest in financial management, to be determined by the instructor. PREREQUISITES: A background in financial management and permission of the instructor.

MN 4154 Financial Management in the Armed Forces (4-0).
Review of financial management concepts and practices in DOD and the Armed Forces, with emphasis on the Department of the Navy. Includes study of PPBS, controllership, budget formulation and execution, headquarters and field activity accounting systems, and various types of funds. PREREQUISITES: MN 2155 or MN 3161 and MN 3172 or the equivalent.

MN 4155 Operational Auditing (4-0).
This course examines auditing as a tool of management control in large, complex organizations. Case studies are used to discuss the scope of the audit, audit procedures, audit findings and recommendations, auditor training and professionalism, and the roles and responsibilities of auditee-managers, users of audit reports, and auditors. The General Accounting Office's audit and internal control standards are also examined, as well as directives of the Office of Management and Budget, Department of Defense, and Department of the Navy. During the last 4-5 weeks, students do field research on an operational audit for a local organization. PREREQUISITE: MN 3161.

MN 4159 Accounting Theory and Standards (4-0).
Advanced study of the basic concepts and standards underlying published financial reports. Specific topics include various approaches to the formulation of accounting standards, bases of asset valuation, alternative concepts of earnings, and measurement of equities. Attention is devoted to alternative accounting methods, controversial reporting issues, and prospective future developments. Current accounting standards are evaluated critically in the light of theoretical constructs. PREREQUISITE: MN 3161.

MN 4161 Financial Management Control Systems (4-0).
Study of the structure and the processes of management control in government organizations. Specific topics include the basic concepts of planning and control, organization of the management control function, measurement of inputs and outputs, pricing government services, programming, budgeting, accounting, and performance evaluation. PREREQUISITES: MN 3105 and MN 2155 or MN 3161.

MN 4162 Cost Accounting (4-0).
Review of basic cost concepts and classifications. Study of cost accounting systems, allocation of direct and indirect costs to cost objectives, and special problems of accounting for materials, direct labor, and factory overhead. Special attention is given to the objectives and the substance of Cost Accounting Standards for negotiated defense procurement contracts. PREREQUISITE: MN 3161.

MN 4163 Analytical Techniques for Financial Control and Planning (4-0).
Study of practical application of quantitative methods in planning and controlling cost. Covered are introductions to the relevant quantitative techniques, the conditions for successful application, and data needed for application. The goal is to provide sufficient background for students to apply analytical techniques to various cost control and planning environments in the public sector. PREREQUISITES: MN 3161, OS 3106.

MN 4301 Contracting for Major Systems (4-0).
Study of the major systems contracting process, procedures and practices. This course focuses on the contracting process of the Systems Commands and the Major Weapons Acquisition Process as described in SECNAVINST 5000.1 that it supports. Major topics include contracting organization for systems acquisition, systems acquisition process, business clearance process, source selection process, multi-year procurement, IMIP and administration of major contracts. Related topics include funding, reliability/maintainability, ILS, foreign military sales and initial provisioning spare parts support. PREREQUISITE: MN 3305 or consent of instructor.

MN 4302 Public Expenditure, Policy, and Analysis (4-0).
The process of federal government decision-making particularly as reflected in the defense budgeting process. Models of budget decision making, including decentralization. Application of social choice concepts. Application from the defense budgeting process. PREREQUISITES: MN 3161, MN 4145.

MN 4310 Logistics Engineering (4-0).
The concept of integrated logistics support and its development. The maintenance concept, functional analysis, life cycle costs, logistics support analysis, human factors in design, provisioning and resupply of repair and spare parts, test and evaluation, and production. PREREQUISITE: OS 3006.

MN 4371 Acquisition and Contracting Policy (4-0).
Seminar utilizing case study appraisals of Government and business acquisition/contracting policies. Emphasis is on acquisition/contracting decision-making and policy formulation. PREREQUISITES: MN 3305 or MN 3371 and permission of instructor.

MN 4372 Seminar in Acquisition and Contract Management (1-0 to 4-0).
Study of a variety of topics of current interest in acquisition and contracting, to be determined by the instructor. PREREQUISITES: A background in acquisition and permission of the instructor.

MN 4373 Transportation Management II (4-0).
A continuation of MN 3373. Concentration on the management of large-scale transportation networks, emphasizing international transportation and the role of the U.S. merchant marine. Also covered are the DOD transportation agencies and current research in transportation. PREREQUISITE: MN 3373.

MN 4376 Seminar in Material Logistics (1-0 to 4-0).
Study of a variety of topics of current interest in logistics, to be determined by the instructor. PREREQUISITES: A background in logistics and permission of the instructor.

MN 4650 The Military Health Care Delivery Systems (4-0).
This course is designed to acquaint the student with the structure and operation of the Department of Defense's system for providing health care to those eligible under current regulations; to identify current problem areas, and through application of systems analysis and management techniques to address the possible solutions to these problems in a course project. PREREQUISITE: MN 3650.

MN 4651 Hospital Economics and Systems Analysis (4-0).
This course deals analytically and empirically with the major organizational and economic structures and problems associated with the operation of a health care delivery facility or group of facilities (e.g., hospitals or integrated groups of clinics). The roles of institutional incentives, methods of reimbursement, provider organization and payment, and exogenous factors such as general inflation and legislative parameters are discussed. The objective is a working background knowledge of these major elements in the health care production process and probable systemic change. PREREQUISITES: MN 3140 and MN 3650.

MN 4652 Micro Health Systems Analysis (4-0).
The purpose of this course is to analyze in-depth, using analyses of extant institutional constructs, the potential for deriving policy recommendations and designing research to motivate more efficient provision of health care by individual facilities. The emphasis will be on identifying gaps in incentives and organizational structures which lead to sub-optimal facility behavior in the cost containment and quality areas. PREREQUISITES: MN 4650 and MN 4651.

MN 4761 Manpower Economics II (4-0).
A continuation and application of theoretical development in MN 3760. Recent applications of economic analysis to manpower, personnel, and training problems are studied. Typical topics include accession, supply models, turnover and retention models, alternative retirement systems, civilian earnings effects of military employment, alternative compensation systems, career mix, and billet cost estimation. PREREQUISITE: MN 3760.

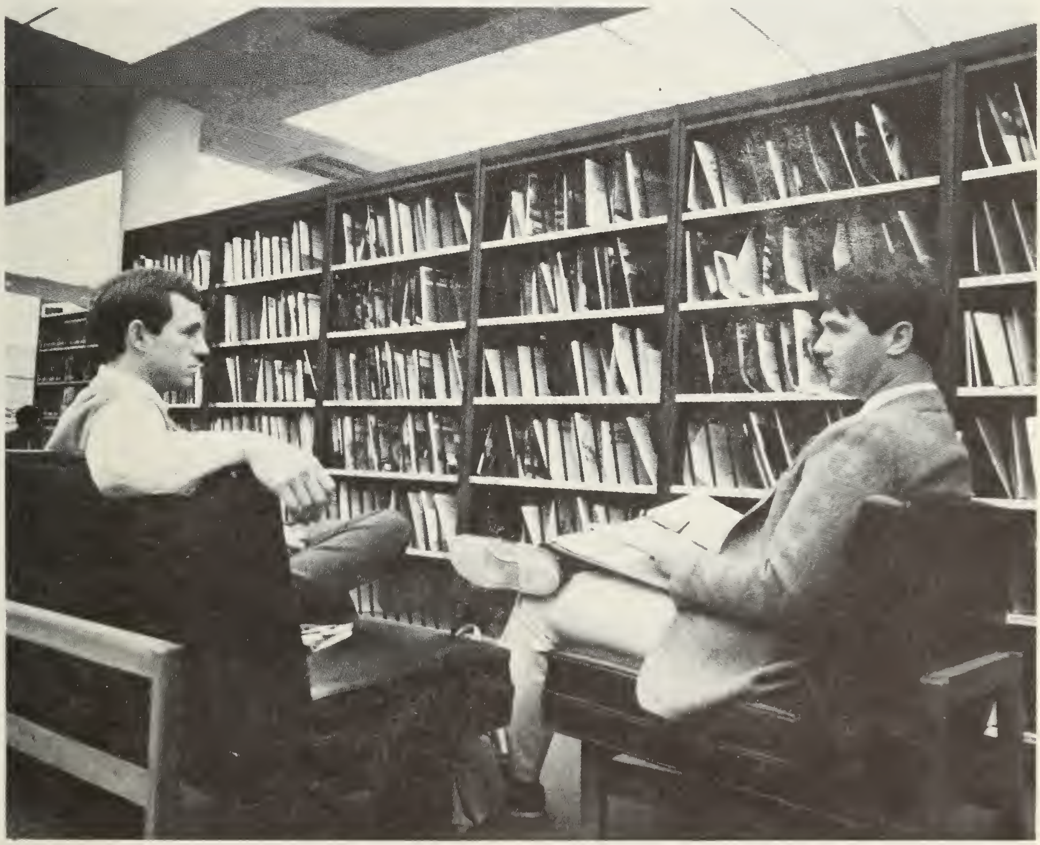
MN 4900 Selected Topics in Administrative Science (1-0 to 4-0).
An individualized program of advanced study in some area of administrative science. PREREQUISITES: A background of advanced work in the area of study and departmental approval. *Graded on Pass/Fail basis only.*

MN 4920 Public Expenditure Analysis (4-0).
A presentation of basic concepts such as public goods, joint production, and externalities which necessitate governmental market intervention. Techniques to analyze the effects and desirability of particular government expenditures are covered and include the theory of second best, cost-benefit analysis, consumer surplus, and social discounting. PREREQUISITE: MN 3172 or AS 3611.

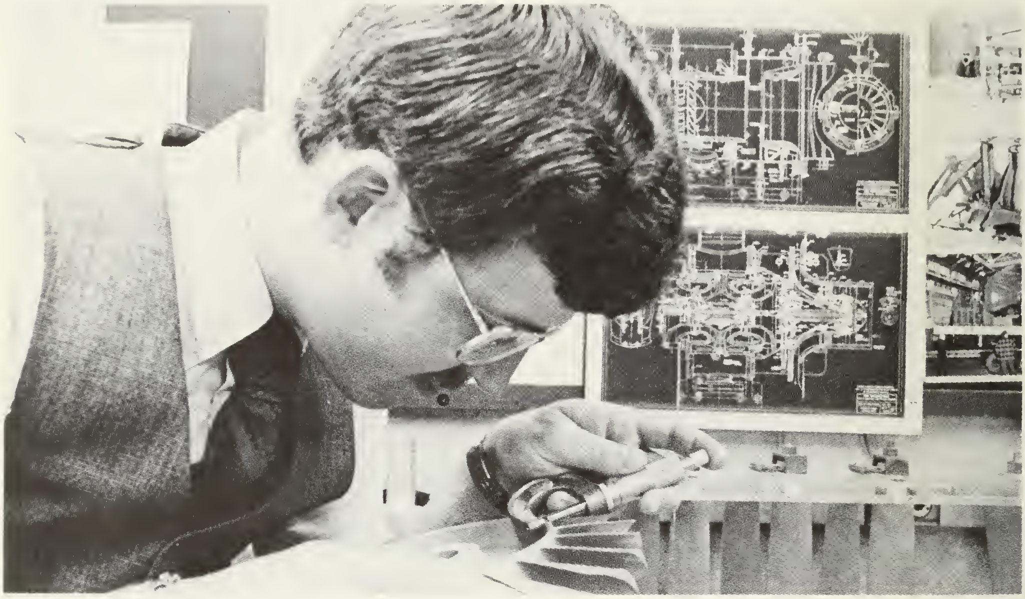
MN 4942 The Structure, Conduct, and Performances of the Defense Industries (4-0).
A study of selected defense industries structure (e.g., seller concentration, product differentiation, barriers to entry, demand for products, buyer concentration), conduct (e.g., pricing policy, product characteristics policy, policies toward rivals, policies toward customers), and performance (e.g., efficiency, progress, employment). The government as consumer and regulator. Typical industries covered are aerospace, computers, shipbuilding, and telecommunications. PRE—REQUISITE: Microeconomics.

MN 4945 Seminar in Economics (1-0 to 4-0).
Study of a variety of topics of current interest in economics, to be determined by the instructor. PREREQUISITES: A background in economics and permission of the instructor.

MN 4970 Seminar in Administrative Sciences (1-0 to 4-0).
Study of a variety of topics of general interest in the administrative sciences, to be determined by the instructor. PREREQUISITES: A background in administrative sciences and permission of the instructor.



DEPARTMENT OF AERONAUTICS



Student checks rotor prior to conducting performance tests in the transonic axial-turbine test rig

Max Franz Platzer, Chairman and Professor of Aeronautics (1970)*; Dipl Ing., Tech. Univ. of Vienna, Austria, 1957; Dr. Techn. Sci., 1964.

Robert Diefendorf Zucker, Associate Chairman and Associate Professor of Aeronautics (1965); B.S. in M.E., Massachusetts Institute of Technology, 1946; M.M.E., Univ. of Louisville, 1958; Ph.D., Univ. of Arizona, 1966.

Robert Edwin Ball, Professor of Aeronautics (1967); B.S. in C.E., Northwestern Univ., 1958; M.S., 1959; Ph.D., 1962.

Richard William Bell, Professor of Aeronautics; (1951); A.B., Oberlin College, 1939; Ae.E., California Institute of Technology, 1941; Ph.D., 1958.

Oscar Biblarz, Associate Professor of Aeronautics (1968); B.S., Univ. of California at Los Angeles, 1959; M.S., 1963; Ph.D., Stanford Univ., 1968.

Tuncer Cebeci, Adjunct Research Professor of Aeronautics (1985); B.S.E.E., Robert College, Turkey, 1958; B.S.M.E., Robert College, Turkey, 1959; M.S.M.E., Duke Univ., 1961; Ph.D., North Carolina State Univ., 1964.

Daniel Joseph Collins, Professor of Aeronautics (1967); B.A., Lehigh Univ., 1954; M.S. in M.E., California Institute of Technology, 1955; Ph.D., 1961.

Allen Eugene Fuhs, Distinguished Professor of Aeronautics and Space Systems (1966); B.S.M.E., Univ. of New Mexico, 1951; M.S.M.E., California Institute of Technology, 1955; Ph.D., 1958.

Theodore Henry Gawain, Professor of Aeronautics (1951); B.S., Univ. of Pennsylvania, 1940; D.Sc., Massachusetts Institute of Technology, 1944.

James Valentine Healey, Adjunct Professor of Aeronautics (1983), M.S. Mechanical Engineering, Columbia University, New York, 1963, Ph.D. Aerospace Engineering, University of Southern California, 1969.

Donald Merrill Layton, Professor of Aeronautics (1965); U.S. Naval Academy, 1945; B.S.A.E., Naval Postgraduate School, 1953; M.S. in A.E., Princeton Univ., 1954; M.S. in Management, Naval Postgraduate School, 1968.

Gerald Herbert Lindsey, Professor of Aeronautics (1965); B.E.S. in M.E., Brigham Young Univ., 1960; M.S. 1962; Ph.D., California Institute of Technology, 1966.

James Avery Miller, Associate Professor of Aeronautics (1963); B.S. in M.E., Stanford Univ., 1955; M.S. in M.E., 1957; Ph.D., Illinois Institute of Technology, 1963.

David Willis Netzer, Professor of Aeronautics, (1968); B.S.M.E., Virginia Polytechnic Institute, 1960; M.S.M.E., Purdue Univ., 1962; Ph.D., 1968.

Raymond Parmous Shreeve, Director, Turbopropulsion Laboratory, and Professor of Aeronautics (1971); B.Sc., Imperial College, London, 1958; M.S.E., Princton Univ., 1961; Ph.D., Univ. of Washington, 1970.

Edward Ming-Chi Wu, Professor of Aeronautics (1984); B.Sc. in M.E., Univ. of Illinois, 1960; M.S. in T.A.M., Univ. of Illinois, 1963; Ph.D., in T.A.M., Univ. of Illinois, 1965.

Emeritus Faculty

Ulrich Haupt, Associate Professor Emeritus (1954); Dipl. Ing., Institute of Technology, Darmstadt, 1934.

George Judson Higgins, Professor Emeritus (1942); B.S., In Eng. (Ae.E.), Univ. of Michigan, 1923; Ae.E., 1934.

Charles Horace Kahr, Jr., Professor Emeritus (1947); B.S., Univ. of Michigan, 1944; M.S., 1945.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN AERONAUTICAL ENGINEERING

The following are academic requirements for the award of degrees as determined by the Department of Aeronautics. In addition, the general minimum requirements as determined by the Academic Council must also be satisfied.

The entrance requirement for study in the Department of Aeronautics generally is a baccalaureate in engineering earned with above average academic performance. This requirement can sometimes be waived for students who have shown distinctly superior ability in backgrounds other than engineering but who have had adequate coverage in the basic physical and mathematical sciences. All entrants must obtain the approval of the Chairman, Department of Aeronautics.

Students who have not majored in Aeronautics, or who have experienced a significant lapse in continuity with previous academic work, initially will take preparatory courses in aeronautical engineering and mathematics at the upper division level, extending through the first three academic quarters and constituting a portion of the coursework for degrees in Aeronautics. Final approval of programs leading to degrees in Aeronautical Engineering must be obtained from the Chairman, Department of Aeronautics.

MASTER OF SCIENCE IN AERONAUTICAL ENGINEERING

Upon completing the preparatory courses, students may be selected on the basis of academic performance for the degree program leading to the Master of Science in Aeronautical Engineering. However, students who have recently earned a degree with major in Aeronautics may apply for admission directly to the graduate program.

The Master of Science degree requires a minimum of 36 credit hours of graduate courses, of which at least 12 credit hours shall be at the 4000 level. It also requires that not less than 32 credit hours shall be in the disciplines of engineering, physical science or mathematics, and that this shall include a minimum of 20 hours of courses in the Department of Aeronautics and a minimum of 8 hours in other departments.

An acceptable thesis is required for the degree unless waived by the Chairman, Department of Aeronautics, in which case 10 quarter hours of 4000 level courses in the disciplines of engineering, physical science, or mathematics will be required in addition to those specified above, increasing the total requirement to 46 quarter hours of graduate level credits.

AERONAUTICAL ENGINEER

Upon completing the equivalent of of two quarters of a graduate program, students may be selected on the basis of academic performance for the program leading to the degree Aeronautical Engineer. Selection to this degree program shall be limited to those students who, in the opinion of the faculty, have the potential to conduct the required research. The degree Aeronautical Engineer requires a minimum of 72 credit hours of graduate courses, of which at least 40 credit hours shall be at the 4000 level. It also requires that not less than 64 credit hours shall be in the disciplines of engineering, physical science, or mathematics, and that this shall include a minimum of 36 hours of courses in the Department of Aeronautics and a minimum of 12 hours in other departments. An acceptable thesis is required for the degree.

Students admitted to work for the degree Aeronautical Engineer may be satisfying requirements for the Master of Science degree concurrently. The Master of Science in Aeronautical Engineering may be conferred at the time of completion of the requirements for that degree.

DOCTOR OF PHILOSOPHY AND DOCTOR OF ENGINEERING

The Department of Aeronautics offers programs leading to the doctorate in the fields of gasdynamics, flight structures, flight dynamics, propulsion, aerospace physics, and aerospace vehicle design.

Entrance into the doctoral program may be requested by officers currently enrolled who have sufficiently high standing. A departmental screening examination will be administered to those so requesting. The Department of Aeronautics also accepts officer students selected in the Navy-wide Doctoral Study Program, and civilian students selected from employees of the United States federal government.

All applicants who are not already enrolled as students in the Department of Aeronautics shall submit transcripts of their previous academic and professional records and letters of recommendation to the Department Chairman. The Chairman, with the advice of other department members, shall decide whether to admit the applicant to the Doctoral Program.

Every applicant who is accepted for the Doctoral Program will initially be enrolled in the AeE Program under a special option which satisfies the broad departmental requirements for the Engineer's degree and which includes research work. As soon as feasible, the student must find a faculty advisor to supervise his research and help him initially in the formulation of his plans for advanced study. As early as practi-

cable thereafter, a Doctoral Committee shall be appointed to oversee that student's individual Doctoral Program as provided in the school-wide requirements for the Doctor's degree.

A noteworthy feature of the program leading to the Doctor of Engineering degree is that the student's research may be conducted away from the Naval Postgraduate School in a cooperating laboratory or other installation of the federal government. The degree requirements are outlined in general school requirements for the Doctor's degree.

In the event that a student is unable finally to satisfy the above requirements for the doctorate for any reason but has in the course of his doctoral studies actually completed all of the requirements for the degree of Aeronautical Engineer, he shall be awarded the latter degree.

AERONAUTICAL LABORATORIES

Six major laboratory divisions support instructional and research programs in subsonic aerodynamics, gas dynamics, rocket and ramjet propulsion, turbomachinery, structures, and composite materials.

The subsonic aerodynamics laboratory consists of two low-speed, continuous flow wind tunnels and a large continuous flow visualization tunnel. Standard techniques are used in the 32 x 45 inch and 42 x 60 inch wind tunnels to study basic fluid flow about bodies, stability and control of flight vehicles, and unsteady flows about bluff bodies and lifting surfaces. Helium bubble filaments are used in the 5 x 5 x 12 foot test section in the three-dimensional flow visualization tunnel to define flow fields of interest, e.g. about helicopter blades, and jet-flap flow.

The gas dynamics laboratory includes a 4 x 4 inch blowdown supersonic wind tunnel, a cold-driven, three-inch double-diaphragm shock tube, and a 2 x 2 x 18 foot open-circuit oscillating flow wind tunnel. Laser interferometers, schlieren systems, hotwire and laser doppler anemometers are used for flow observations. Ruby, He-Ne, argon and CO lasers are available; extensive use is made of laser holography. An electrohydrodynamic research facility permits studies of electric power generation, turbulence, and fuel sprays into gas turbine combustors.

The combustion laboratory consists of an instrumented control room, a propellant evaluation laboratory, a high pressure air facility, and three test cells. The test cells are equipped with diagnostic apparatus and motor hardware for investigating solid, liquid, gaseous, and hybrid rocket, solid fuel ramjet and gas turbine combustion.

The Turbopropulsion Laboratory (TPL) houses a unique collection of experimental facilities for research and development related to compressors, turbines and advanced air-breathing propulsion-engine concepts. In a complex of specially designed concrete structures, one building, powered by a 750 HP compressor, contains 10″ by 60″ rectilinear and 4′ to 8′ diameter radial cascade wind-tunnels and a large 3-stage axial research compressor for low speed studies. A second building, powered by a 1250 HP compressed-air plant, contains fully instrumented transonic turbine and compressor test rigs in explosion proof test cells. A spinpit for structural testing of rotors to 50,000 rpm and 1800°F is provided. Model experiments and equipment for instrumentation development are located in a separate laboratory. Data acquisition from 400 channels of steady-state and 16 channels of non-steady measurements at up to 100 kHZ is controlled by the laboratory's HP 1000 series computer system. On-line reduction and presentation of data with time sharing are available to multiple users. Terminals for HP 9845 and the central IBM 370-3033 computers are available for data analysis or flow computation.

The structural test laboratory contains testing machines for static and dynamic tests of materials and structures, and an electro-hydraulic closed-

loop machine for fatigue testing. Aircraft components as large as complete aircraft wings are accommodated on a special loading floor, where static and vibration tests are conducted. A well-equipped dynamics laboratory contains shaker tables, analog computers, and associated instrumentation. An adjacent strain gage and photo-elastic laboratory provides support to test programs and instruction in structural testing techniques.

The Mechanics of Materials for composites laboratory is equipped with fabrication and testing facilities for characterizing the mechanical behavior of fiber-reinforced composites. The fabrication facilities include an oven and press with provisions for computer control of temperature and pressure profile for fabrication of laminates and strands. The testing facilities include five mechanical driven universal testing machines for general testing and for life testing. These testing facilities are supported by a wide array of modern data acquisition instruments including computer controlled data-loggers, digital voltmeters, acoustic emission analyzer, spectrum analyzer, and laser diffraction instruments. Personal computers and a VAX-725 provide ample capacity for analytical interpretation of data and for model formulation.

In addition to the major laboratory facilities, which include extensive instrumentation and data processing capabilities, the department possesses an IBM Series 1 computer with several input/output terminals and graphic/plotting displays. Other research facilities include a laboratory for investigating torpedo warheads, a number of flight simulators used with hybrid comuters for studying pilot/control system interactions. The department also uses a leased aircraft for an in-flight laboratory.

SPACE SYSTEM LABORATORIES

Laboratories which support the Space Systems Programs are located in several departments including Physics, Oceanography and Electrical and Computer Engineering. Refer to the appropriate part of the catalog for descriptions. Aeronautics has developed a Solar Simulator laboratory which features a 2500W source. Experiments are computer controlled using IBM/PC with ISAAC 2000 controller. Solar cells can be tested for radiation damage using the LINAC or Pulserod sources which are located in Physics. The Laser Damage Facility is a Joint Physics/Aeronautics laboratory developed to support instruction and research related to such topics as satellite vulnerability. The Laser Damage Facility features a pulsed CO_2 electrical laser with sufficient irradiance to generate laser supported detonation waves. An optics laboratory is also available which utilizes lasers for such space functions as remote sensing in addition to precision optical measurements.

DEPARTMENTAL COURSE OFFERINGS

AERONAUTICS

AE 0010 Aeronautical Engineering Seminar (0-1).
Oral presentations of material not covered in formal courses. Topics cover a wide spectrum of subjects ranging from reports of current research to survey treatments of fields of scientific and engineering interest.

AE 0020 Aeronautical Engineering Program Planning (0-1).
Oral presentations by the Aeronautics Academic Associate and faculty members involved in research with Aeronautical students on program planning, thesis requirements and research specialty areas.

AE 0810 Thesis Research (0-0).
Every student conducting thesis research will enroll in this course.

Upper Division Courses

Some preparatory courses in Aeronautics are available through the Continuing Education Division. These one-credit hour mini-courses have been prepared in a self-instructional mode (PSI) and complete des-

criptions for each mini-course may be found in the Continuing Education catalog. The mini-courses are equivalent to, and may be substituted for, the on-campus courses as follows:

Campus Course	*Equivalent mini-course sequence*
AE 2021	AE 2101 through 2106
AE 2042	AE 2401 through 2404

AE 2015 Engineering Dynamics (3-2).
Fundamental physical concepts; dynamics of particles and of systems of particles; concepts of work-energy and impulse-momentum; rigid-body dynamics in two dimensions. PREREQUISITE: MA 2121.

AE 2021 Introduction to Flight Structures (4-1).
Introduction to concepts of stress and strain, and mechanical behavior of materials. Bending and torsional stress and deflection analysis of representative aero-structural components, including statically indeterminate cases. Introduction to stability analysis, and energy methods. *(May be taken through Continuing Education as mini-courses AE 2101-06.)*

AE 2035 Basic Aerodynamics (3-2).
Continuity/Momentum equations; dimensional analysis; elements of two dimensional ideal flow; thin-airfoil, finite wing theory. PREREQUISITE: AE 2042.

AE 2036 Performance and Stability (3-2).
Model atmosphere; defined airspeeds; aircraft performance including climb, range, endurance and energy management; principles of longitudinal, lateral and directional static stability and control of aircraft. PREREQUISITE: AE 2035.

AE 2042 Fundamentals of Thermo-Fluid Dynamics (3-2).
Properties of fluids. Principles of continuity, momentum, and energy for incompressible and compressible fluids; control volume formulations. Second law of thermodynamics, entropy and irreversibilities; equations of state, properties of pure substances; power cycles. Viscous flows, boundary layer concepts. *(May be taken through Continuing Education as mini-courses AE 2401-2404.)*

AE 2043 Fundamentals of Gas Dynamics (3-2).
Concepts of compressible flows, adiabatic/isentropic flow; normal shocks, moving and oblique shocks, Prandtl-Meyer flow; Fanno and Rayleigh flow; introduction to reaction propulsion systems. PREREQUISITE: AE 2042.

AE 2801 Aero-Laboratories I (3-2).
An introduction to modern experimental techniques and instrumentation. Lectures and demonstrations in the use of sensing devices and data acquisition systems, data reduction and analysis, report writing. Selected experiments in all aeronautical laboratories. PREREQUISITES: AE 2021, 2035, 2043, and 2015 (concurrent) or equivalent.

AE 2802 Aero-Laboratories II (1-3).
Selected experiments in all aeronautical laboratories. PREREQUISITE: AE 2801.

Upper Division or Graduate Courses

AE 3005 Survey of Aircraft & Missile Technology (4-0).
(For Non-Aeronautical Engineering Students) A survey of aeronautical engineering concepts as applied to airplanes and missiles, starting with explanations of the basic principles of aerodynamics, performance, propulsion, etc., and extending to examples of these principles in present-day hardware.

AE 3101 Flight Vehicle Structural Analysis (3-2).
Graduate core course in structures covering basic definitions and field equations for solid bodies, two-dimensional stress and analysis, thin skin and thick skin wing bending analysis, fracture and fatigue theory. PREREQUISITE: AE 2021 or equivalent.

AE 3201 System Safety Management and Engineering (3-2).
An introduction to System Safety, with emphasis on the requirements imposed by MIL-STD-882A. Fundamental mathematical concepts (probabilities, distribution theory, Boolean algebra); safety analysis techniques (hazard analysis, fault-tree analysis, sneak circuit analysis); safety criteria, tasks, data, and documentation; lifecycle considerations.

AE 3251 Aircraft Combat Survivability (4-1)).
This course brings together all of the essential ingredients in a study of the survivability of fixed wing, rotary wing and missile aircraft in a hostile (non-nuclear) environment. The technology for increasing survivability and the methodology for assessing the probability of survival in a AAA/SAM/Laser environment are presented in some detail. Topics to be covered include: current and future threat descriptions; the mission/threat analysis; combat data analysis of SEA and Mid-East losses; vulnerability reduction techniques and technology for the major aircraft systems; susceptibility reduction concepts and equipment for reducing the probability of detection and avoidance of the threat; and vulnerability, susceptibility and survivability assessment and trade-off methodology. In-depth studies of the survivability of several fixed wing and rotary wing aircraft will be presented. PREREQUISITE: U.S. Citizenship and SECRET clearance.

AE 3340 Linear Vibration and Dynamic Stability (3-2).
Single and multiple degree of freedom systems; damped/undamped; free/forced response. Continuous systems. Stability derivatives; aircraft equations of motion; uncoupled and cross-coupled modal solutions. PREREQUISITES: AE 2015 and 2036.

AE 3341 Control of Aerospace Vehicles (3-2).
Elements of classical control analysis as applied to aircraft and missiles; Bode, Nyquist, Root Locus methods; compensators, autopilot design, stability augmentation systems. State-variable methods, state-variable feedback, controllability, observability, and introduction to discrete systems. PREREQUISITES: EE 2402, and AE 3340.

AE 3304 Rotary Wing Aircraft Technology (3-2).
(For Non-Aeronautical Engineering Students) A course designed to familiarize the student with the major aerodynamic, propulsion, structural, and stability and control aspects of rotary wing aircraft, past and current helicopter developments, technology status and problems. PREREQUISITE: Consent of Instructor.

AE 3305 V/STOL Aircraft Technology (4-0).
(For Non-Aeronautical Engineering students) Basic aerodynamic and propulsion principles and phenomena, past and current vertical take-off and landing aircraft developments, current technology status and problems. U.S. Navy V/STOL aircraft requirements and acquisition programs. Russian V/STOL aircraft and assessment of USSR-V/STOL aircraft technology and trends, impact of V/STOL aircraft technology on naval systems acquisition and operations. PREREQUISITE: Consent of Instructor.

AE 3451 Aircraft and Missile Propulsion (3-2).
Description, design criteria, analysis and performance of ramjets, turboprops, turbojets, and turbofans. Analysis of components: inlets, compressors, combustors, turbines and nozzles. Current state-of-the-art and impact of trends in propulsion technology. PREREQUISITE: AE 2043.

AE 3501 Current Aerodynamic Analysis (3-2).
Introduction to current aerodynamic analysis methods for subsonic and supersonic flight vehicles. Developments proceed from the three-dimensional Navier-Stokes equations to various approximation methods, such as linearized, inviscid, subsonic and supersonic panel methods for wing-body combinations; discussion of sweep-back effect and area rule; laminar and turbulent boundary layer analysis; use of state-of-the-art computer programs. PREREQUISITES: AE 2043 and AE 2035.

AE 3900 Special Topics in Aeronautics (Variable credit up to five hours.)
Directed graduate study or laboratory research. Course may be repeated for additional credit if topic changes. PREREQUISITE: Consent of Department Chairman.

Graduate Courses

AE 4102 Advanced Aircraft/Missile Structural Analysis (3-2).
The finite element method of structural analysis will be studied and applied to aircraft and missile structures. Capabilities of the current finite element computer programs will be discussed. An introduction to the theory of structural dynamics and stability will also be presented. PREREQUISITE: AE 3101.

AE 4103 Advanced Aircraft Construction (3-2).
A course covering the manufacturing techniques and analysis of composite materials and sandwich construction. Theories of failure, damage and repair. Advanced design concepts. PREREQUISITE: AE 3101.

AE 4202 Reliability in Structures and Materials (3-0).
A course providing the background and specifics associated with the design, certification and maintenance of structures in critical applications. The background includes an introduction to probability, reliability in design, and statistical modeling. The specifics includes reliability, testing and statistical modeling of structures with applications to materials development, life durability characterization, proof-test, and maintenance of advanced composite materials. PREREQUISITE: Graduate Standing in an Engineering/Science Curriculum.

AE 4273 Aircraft Design (3-2).
A course in conceptual design methodology which centers around an individual student design project. It draws upon all of the aeronautics disciplines and provides the student with experience in their application to design. PREREQUISITE: Completion of the Aero Graduate Core.

AE 4304 Helicopter Performance (3-2).
The performance characteristics of rotary wing aircraft. Blade motion, momemtum theory, blade element theory, tip loss factor, ground effect, hover, vertical flight, forward flight, climbing flight, autorotation, tail rotors, range and endurance, and multiple rotors. Numerical problems in helicopter performance. PREREQUISITE: Aero Preparatory Phase or equivalent.

AE 4305 V/STOL Aircraft Technology (3-2).
Types of V/STOL aircraft, fundamental principles, main performance characteristics, and propulsion requirements, STOL technology: mechanical high-lift devices, powered-lift devices, jet flaps, augmentor wings; VTOL technology: flow vectoring devices, lift engine and lift fan technology, augmentor wings; airframe/propulsion system interactions, ground interference effects: V/STOL stability and control considerations, handling qualities; review of current development programs, NAVY V/STOL requirements and programs. PREREQUISITE: Aero Graduate Core or permission of Instructor.

AE 4306 Helicopter Design (3-2)
Engineering problems that are to be found in rotary-wing design are presented for solution to develop a basic understanding of the conceptual design process for both single and multi-rotor helicopters. Interfaces of sub-systems and the required design trade-offs, including economic and operational factors, are emphasized. A preliminary design of a single rotor helicopter is conducted to meet specified requirements and the performance of the resulting vehicle is evaluated. PREREQUISITE: AE 4304.

AE 4307 Advanced Helicopter Design (3-2).
An extension of the conceptual design concept to a more detailed design. Elements of static and dynamic stability, control, weight and balance, detailed sizings, and effects of parameter variation are considered. The detailed design will usually be limited to an expansion in but a single area. PREREQUISITE: AE 4306.

AE 4318 Aeroelasticity (4-0).
Response of discrete and continuous elastic structures to transient loads and to steady oscillatory loads, utilizing matrix methods. Static aeroelasticity problems in aircraft, non-stationary airfoil and wing theory. Unsteady missile aerodynamics. Application to the flutter problem. Transient loads, gusts, buffet, and stall flutter. PREREQUISITE: AE 3340.

AE 4323 Flight Evaluation Techniques (3-2).
Quantitative and qualitative techniques for the evaluation of aircraft performance and handling qualities of flight; aircraft data acquisition systems; normalizing and standardizing of flight test data; pilot rating scales; effects of design parameters; application of specifications to flight evaluations. In-flight laboratory is provided. PREREQUISITE: AE 3340.

AE 4342 Advanced Control for Aerospace Systems (3-2).
State variable analysis including state variable feedback and state variable estimators (observers). Optimal control; digital fly-by-wire systems. Topics from non-linear systems and/or stochastic control. PREREQUISITE: AE 3341.

AE 4343 Guided Weapon Control Systems (3-2).
Detailed analysis of tactical missiles, per-

formance of target trackers, basic aerodynamics of missiles, missile autopilot design, missile servos and instruments, line of sight guidance loops, terminal guidance, proportional navigation. PREREQUISITE: AE 3341 or equivalent.

AE 4431 Aerothermodynamics & Design of Turbomachines (3-3).
Flow and energy exchange in compressors and turbines, and current engineering methods for their aerodynamic design, test, and measurement. PREREQUISITE: Aero Preparatory Phase or equivalent.

AE 4452 Rocket and Missile Propulsion (4-0).
Applications and analysis of solid-propellant rockets, ramjets and ducted rockets. Propellant selection criteria and characteristics, combustion models and behavior, performance analysis, technology requirements. PREREQUISITE: AE 3451.

AE 4502 High-Speed Aerodynamics (4-0).
Nonlinear and linearized analysis of inviscid subsonic and supersonic flow over wings and bodies. Steady and unsteady phenomena. Method of characteristics. Method of distributed singularities. Computer solution of typical problems. If class progress warrants, instructor may elect to present additional topics on transonic flow. PREREQUISITE: AE 3501.

4503 Missile Aerodynamics (4-0).
The aerodynamics of missiles and guided projectiles for various speed regimes and motions. Topics include slender body and linearized theory as well as nonlinear aerodynamic effects, coupling effects, Magnus effects, etc. The impact of these effects on missile flight dynamics, guidance and control is included. PREREQUISITE: AE 3501.

AE 4504 Convective Heat and Mass Transfer (4-0).
Convective heat and mass transfer on internal and external flow systems common to aerospace vehicles; laminar and turbulent flows. Analytic techniques, integral and numerical methods, experimental correlations. Effects of variations in thermophysical properties. PREREQUISITE: AE 3501.

AE 4505 Laser/Particle Beam Technology (3-2).
Survey of different types of particle beams, including electrical, gasdynamic and chemical lasers, electron beams; resonator cavities for lasers and external propagation mechanisms; high energy lasers and charged particle beams, military applications. PREREQUISITE: Consent of Instructor.

AE 4506 Rarefied Gas Dynamics (4-0).
Topics include kinetic theory, distribution functions, Boltzmann equation, transport phenomena from a kinetic theory viewpoint, free molecular flow, transitional flow between continuum and free molecular flow, dynamic coefficient and numerical solutions. PREREQUISITE: Consent of Instructor.

AE 4632 Computer Methods in Aeronautics (3-2).
Use of the digital computer in numerical methods. Classification of Aeronautical Engineering problems as equilibrium, eigenvalue or propagation problems. Computer solution procedures developed for the ordinary and partial differential equations of gas dynamics, heat transfer, flight mechanics and structures. PREREQUISITE: Aero Preparatory Phase or equivalent.

AE 4641 Aeronautical Data Systems (3-2).
A design-project-oriented course utilizing microprocessor technology with emphasis upon aeronautical engineering applications. Both software and hardware aspects of system integration will be considered for engineering tradeoffs during problem definition and solution. PREREQUISITE: EE 2811 or equivalent.

AE 4900 Advanced Study in Aeronautics (Variable credit up to five hours.)
Directed graduate study or laboratory research. Course may be repeated for additional credit if topic changes. PREREQUISITE: Consent of Department Chairman.

WEAPONS ENGINEERING and SPACE SCIENCE COURSES

Upper Division or Graduate Courses

AE 3001, Space Systems Laboratory (0-2).
The laboratory will be used to support the Naval Postgraduate School (NPS) experiments to be flown on board Space Shuttle or on other Spacecraft. The laboratory does not consist of canned experiments; the specific activity depends on the nature of the experi-

ment currently being prepared for flight. Course may be repeated for additional credit to continue work on the project. PREREQUISITE: Consent of Instructor.

AE 3701 Missile Aerodynamics (4-1).
Potential flow, thin-air-foil and finite wing theories. Linearized equations, Ackeret theory, Prandtl-Glauert transformations for subsonic and supersonic wings. Planform effects. Flow about slender bodies of revolution, viscous crossflow theory. PREREQUISITE: AE 2043.

AE 3705 Warheads and Lethality (4-1).
This course examines the design and the effectiveness of missile warheads for use against air targets. The generation of the damage mechanisms, such as blast, fragments, and incendiary particles, is studied for several types of warheads. The functions of fuzes and their modes of operation for target sensing are also discussed. The vulnerability of the target to the damage mechanisms is examined, and the procedures for assessing the measures of target vulnerability are described. The assessment of the effectiveness of the warhead, as measured by the probability of target kill given a detonation, is made in the Endgame analysis. Total missile lethality is evaluated by determining the probability of target kill, given a single missile launch. Target countermeasures for reducing the missile lethality are also described.

AE 3711 Missile Flight Analysis (4-0).
Methodology, with numerical examples, for assessing the capabilities/limitations dictated by aerodynamic shapes and propulsion systems on tactical missile trajectories, at high (surface-air, air-air, etc.) and low (cruise missile) thrust-to-weight. Aft-tail or canard, single or dual symmetry configurations. PREREQUISITE: Completion of an Engineering/Science Core or equivalent.

AE 3791 Spacecraft Systems I (3-2).
Examination of the factors affecting space systems selection and design, impact of orbital and sensor characteristics, ground facilities requirements, manufacturing, testing and verification techniques and requirements. Payload design considerations including impact of antennas, RF environment and EMI. Mechanical and electrical design of space systems. Temperature control. Attitude control. Special techniques associated with large space structures. PREREQUISITES: PH 3111, Completion of Space Curricula Core or equivalent. SECRET clearance.

AE 3792 Spacecraft Systems II (4-0).
Survivability of space systems in wartime is discussed along with design features to improve protection. Case studies are selected to emphasize and illustrate material presented previously in AE 3791 as well as material in AE 3792. The students design a space system to meet mission requirements. PRE—REQUISITE: AE 3791. SECRET clearance.

AE 3795 Introduction to Space Warfare (4-0).
An overview of projected space technologies, possible weapons for space (e.g., lasers), need for a manned space operational center, hypothetical scenarios for space operations, requirements for future space transportation systems, and joint civil and military programs. In addition to the descriptive material, the course includes a technical introduction to orbital mechanics, launch vehicle propulsion, and aerothermodynamics. PREREQUISITES: SECRET clearance and consent of Instructor.

Graduate Courses

AE 4702 Missile Propulsion (4-0).
Applications and analysis of solid propellant rockets, ramjets and ducted rockets. Propellant selection criteria and characteristics, combustion models and behavior, performance analysis, technology requirements. PREREQUISITE: AE 3701.

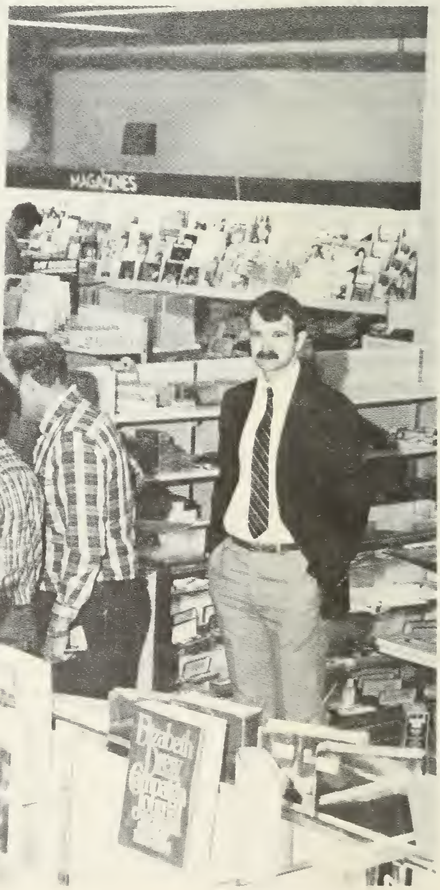
AE 4703 Missile Stability and Performance (4-1).
Static and dynamic stability and control. Neutral points, control effectiveness, trim in maneuvering flight. Configuration determinants (canard, aft-control; interior arrangement). Transient (dynamic) modes. Subsonic, transonic, supersonic force and moment data for performance calculations with short and long-range cruciform missiles and cruise missiles: acceleration, climb, ceiling, range and agility in maneuvering trajectories. PREREQUISITE: AE 3701.

AE 4704 Missile Configuration and Design (3-2).
A project oriented course centering on the design of a missile by each student. Principles of aerodynamics, guidance, control, propulsion, and structures will be used to synthesize a missile to respond to a specified threat. PREREQUISITE: AE 4702 and AE 4703 or completion of the Aero Graduate Core.

AE 4706 High Energy Laser System Design (4-0).
Types of lasers including excimer lasers. Laser performance. Adaptive optics. Propagation of laser beams. Pointing and tracking. Acquisition and handoff. Fire control. Damage mechanisms. Advantages and limitations of both CW and Pulsed. Applications include ASMD, SAM-suppression, anti-tank optics, and space warfare. High energy laser systems are contrasted with other directed energy concepts. Students design a complete laser system. PREREQUISITE: Completion of an Engineering/Science Core or equivalent.

AE 4709 Strategic Missile Systems (4-0).
Overview of Triad. Submarine as a launch platform. Underwater launch. Trident missile system. Factors influencing CEP. Reentry body design features. Maneuvering reentry bodies. Reentry phenomena. Penetration aids. Aspects of ballistic missile defense. Communication with submarines; blue-green lasers. Use of USN and national space assets to support Trident. PREREQUISITE: Completion of an Engineering/Science Core or equivalent. SECRET clearance.

AE 4712 Missile Systems Design and Integration (3-2).
Propulsion technology assessment of air-breathers and rockets. Boost, midcourse, terminal guidance and control concepts. Homing guidance law kinematics; target tracker performance. Missile dynamics. Mission profiles; trajectory shaping. Warhead lethality. Airframe structural features. Body/wing aerodynamic design precepts. Synthesis of above to baseline missile definition. PREREQUISITE: AE 3711.



ANTISUBMARINE WARFARE GROUP

Analysis of the operational employment of ASW assets such as the SH-3A helicopter shown here is supported by the courses in the antisubmarine warfare curriculum

The Antisubmarine Warfare Academic Group has administrative responsibility for the academic content of the Antisubmarine Warfare Program. Teaching in this program is carried out by faculty members attached to the various Academic Departments associated with the Program.

Robert Neagle Forrest, Professor of Operations Research; Chairman (1964)*; B.S., Univ. of Oregon, 1950; M.S., 1952; M.S., 1954; Ph.D., 1959.

Robert Hathaway Bourke, Associate Professor of Oceanography (1971); B.S., Naval Academy, 1960; M.S., Oregon State Univ., 1969; Ph.D., 1972.

Alan Berchard Coppens, Associate Professor of Physics (1964); B. Eng. Phys., Cornell Univ., 1959; M.S., Brown Univ., 1962; Ph.D., 1965.

Donald Charles Daniel, Associate Professor of Political Science (1975); B.A., Holy Cross College, 1966; Ph.D., Georgetown Univ., 1971.

John Norvell Dyer, Professor of Physics (1961); B.A., Univ. of California at Berkeley, 1956; Ph.D., 1960.

Carl Russell Jones, Professor of Administrative Sciences (1965); B.S., Carnegie Institute of Technology, 1956; M.B.A., Univ. of Southern California, 1963; Ph.D., Claremont Graduate School, 1965.

John Harvey Long, Commander, U.S. Navy; Curricular Officer, (1984); B.S.M.E., U.S. Naval Academy, 1971; M.S., Naval Postgraduate School, 1978.

James Vincent Sanders, Associate Professor of Physics, (1961); B.S., Kent State Univ., 1954; Ph.D., Cornell Univ., 1961.

Rex Hawkins Shudde, Associate Professor of Operations Research (1962); B.A. and B.S., Univ. of California at Los Angeles, 1952; Ph.D., Univ. of California at Berkeley, 1956.

Charles William Therrien, Associate Professor (1984); S.B. and S.M., Massachusetts Institute of Technology, 1965; Ph.D., 1969.

Carroll Orville Wilde, Professor of Mathematics (1968); B.S., Illinois State Univ., 1958; Ph.D., Univ. of Illinois, 1964.

**The year of joining the Postgraduate School faculty is indicated in parenthesis.*

MASTER OF SCIENCE IN SYSTEMS TECHNOLOGY

1. The degree of Master of Science in Systems Technology will be awarded at the completion of an interdisciplinary program carried out in accordance with the following degree requirements:

   a. The Master of Science in Systems Technology requires a minimum of 45 quarter hours of graduate level work of which at least 15 hours must represent courses at the 4000 level. Graduate courses in at least four disciplines must be included and in three disciplines, a course at the 4000 level must be included.
   b. An approved sequence of at least three courses constituting advanced specialization in option area must be included.
   c. In addition to the 45 hours of course credit, an acceptable group project or thesis must be completed.
   d. The program must be approved by the Chairman of the ASW Group.

DEPARTMENTAL COURSE OFFERINGS

ST 0001 Seminar (0-1).
Special Lectures, and discussion of matters related to the ASW Program. PREREQUISITE: Enrollment in the ASW Curriculum and SECRET clearance.

ST 0810 Thesis Research/Group Project (0-0).
Students in the ASW Curriculum will enroll in this course while doing either an individual thesis or an equivalent group project involving several students and faculty.

ST 1810 Introduction to Programmable Calculators (4-1).
An introduction to the operation and programming of calculators and computers that are used in the ASW Curriculum. *Graded on Pass/Fail basis only.*

Upper Division or Graduate Course

ST 3000 Study Project On ASW Systems Performance (0-2).
This is a project course in which the project is a study and analysis of the performance of an assigned type of ASW system under a variety of operating conditions. PRERE—QUISITE: Enrollment in the ASW Curriculum or consent of the Group Chairman and SECRET clearance. *Graded on a Pass/Fail basis only.*

Graduate Course

ST 4999 Special Studies in ASW (1-0 to 4-0).
A course designed to meet the needs of students for special work in advanced topics related to ASW. PREREQUISITE: Enrollment in the ASW Curriculum and consent of the Group Chairman.

AVIATION SAFETY PROGRAMS

Instructors MAJ John Lemoine and MAJ Joe Schmid demonstrate controlability functions of helicopter model

Jimmy W. Davis, Captain, U.S. Navy; Director; B.A., Naval Postgraduate School 1965; Masters Political Science, Auburn Univ., 1970.

Milton Harold Bank, II, Associate Professor of Aeronautical Eng. and Safety (1971); B.S., U.S. Naval Academy, 1957; B.S.A.E., Naval Postgraduate School, 1964; Ae.E., Stanford Univ., 1967; M.S., Georgia Institute of Technology, 1970; Ph.D., 1971.

Russell Branson Bomberger, Professor of Law and Psychology (1958); B.S., Temple Univ., 1955; Ll.B., LaSalle Univ., 1968; J.D., 1969; M.A., Univ. of Iowa, 1956; M.S., Univ. of Southern California, 1960; M.A., Univ. of Iowa, 1961; Ph.D., 1962.

William Donald Fraser, Commander, U.S. Navy; Instructor in Aviation Safety Command Course (1982); B.A., San Diego State University, 1966; M.S.S.M., Univ. of Southern California, 1984.

Anthony O. Honeycutt, Commander, U.S. Navy; Instructor in Aviation Mishap Investigations (1984); B.A., North Carolina State University, Raleigh.

Neil Randolph Justice, Major, U.S. Marine Corps; Instructor in Aircraft Mishap Reporting, and Safety Program Management and Aircraft Accident Prevention (1983); B.S., King College, 1969.

Edward John Kennedy, Associate Professor of Aviation Physiology (1972); M.D., Univ. of Iowa College of Medicine, 1962.

John A. Lemoine, Major, U.S. Marine Corps; Engineering and Safety (1985); B.S.G., Villanova University, 1973; M.S.A.E., Naval Postgraduate School, 1984.

Edward F. Robbins, Lieutenant Commander, U.S. Navy; Instructor in Aeronautical Engineering and Safety (1983); B.A., St. Joseph's College, 1968, MSAE, Naval Postgraduate School, 1976.

Paul E. Yoos, Lieutenant Commander, U.S. Navy; Instructor in Aircraft Mishap Reporting (1984); B.A., Rutgers University, 1972.

**The year of joining the Postgraduate School faculty is indicated in parentheses.*

AVIATION SAFETY OFFICER COURSE

An Aviation Safety Officer (ASO) course is offered eight times per year on a temporary additional duty basis for those commands needing a trained Squadron Safety Officer/Aviation Safety Officer. The course prepares safety officers at the squadron level to assist commanding officers in conducting an aggressive accident prevention program. When the SSO/ASO completes this course he will be able to organize and administer an accident prevention program at the squadron level as defined in OPNAVINST 5100.8.

The six week course consists of approximately 190 classroom hours of safety program management, including mishap prevention techniques, operational aerodynamics and aircraft structures, mishap investigation and reporting, pyschology, law, and aeromedical support. Prior completion of college level courses in algebra and/or physics is highly desirable. A two-day field trip will be made, to conduct a Safety Survey of an operating squadron or air station.

Designated naval aviators and naval flight officers of the Navy and Marine Corps of the rank of Lieutenant, USN, and Captain, USMC, and above are eligible to attend. Exceptions must be approved by Type Commanders, or CMC, as appropriate. Details of quota control and class schedules are defined in NPSNOTICE 1520.

RESIDENT COURSES

Officers regularly enrolled in other curricula of the Postgraduate School may qualify for the Aviation Safety Officer Certificate by completing the program requirements: AO 2020, AO 2030, AO 3000, AO 3050, and AO 3060. Substitutions for some of these courses may be made by taking equivalent courses in other departments upon approval of the Director of Aviation Safety. Examples: AO 2020 may be replaced by upper division or graduate courses in aeronautical engineering covering similar topics. AO 3040 may be replaced by upper division or graduate courses in psychology covering similar topics.

AVIATION SAFETY COMMAND COURSE

The Aviation Safety Command (ASC) course is offered ten times a year on a temporary additional duty basis to commanding officers, executive officers, OinC's and officers screened for aviation command. This course consists of approximately 41 hours of such subjects as safety program management, safety psychology, aviation law, aircraft systems, and incidents/accident endorsements. No academic credit is available for this course.

DEPARTMENTAL COURSE OFFERINGS

Upper Division Courses

AO 2020 Aerodynamics for Aircraft Accident Prevention and Investigation (3-0).
Survey of aerodynamics, performance, stability and control of fixed wing/rotary wing aircraft. Effects of varying conditions, configurations, designs and crew techniques on critical areas of operation.

AO 2030 Aircraft Structural Analysis (1-0).
Strength of materials, design criteria, failure mechanisms. Recognition of failures, fatigue, brittle fractures, contribution of manufacturing and maintenance, analysis of evidence, corrosion control technology, and quality control concepts.

Uper Division or Graduate Courses

AO 3000 Problems in Accident Prevention and Investigation (0-4).
Management Theories, practices and techniques, developing applications for the organization and control of a squadron mishap prevention program. Problem-solving exercises in the application of system safety concepts in the squadron accident prevention and investigation effort. Through case-study methods, the course emphasizes mission accomplishment, conservation of resources, cost effectiveness, and systems management in accident prevention, investigation, and reporting.

AO 3040 Safety Psychology (1-0).
Study of human reliability in survival-value environments; personality elements in safety motivation; identification and reduction of problems in human reliability.

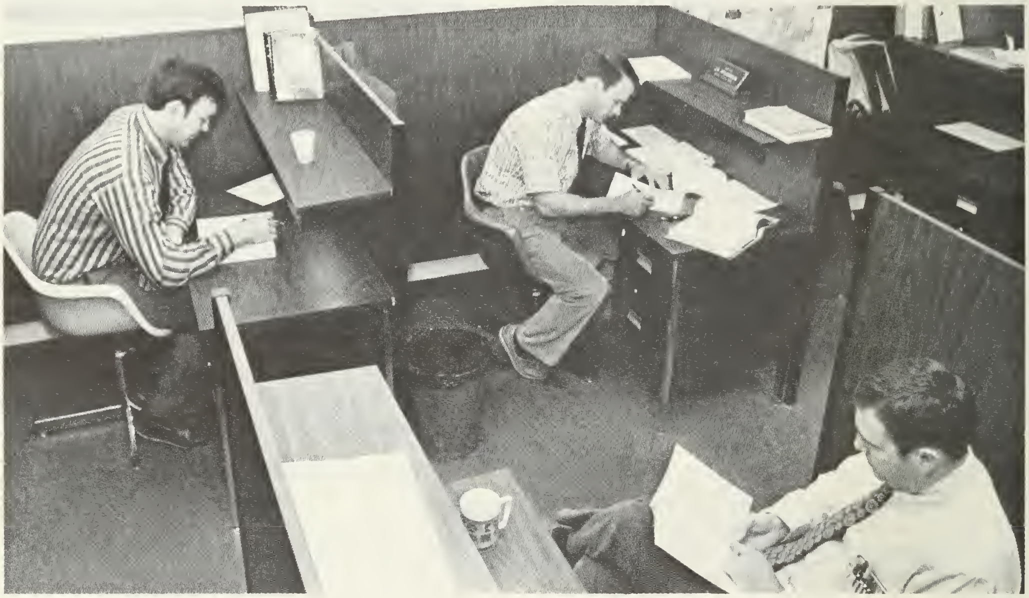
AO 3050 Safety Law (1-0).
Study of leading cases and statutes concerning rights and duties in the safety disciplines. Emergency claims; quasicontractural duties. Criminal prosecution of safety violations. Legal duties of care. Special rules of evidence used by the courts in safety-related disputes.

AO 3060 Problems in Aviation Medicine (1-0).
Life-science considerations in accident prevention and investigation. Medical prediction. Effects of hypoxia, dysbarism, G-forces, spatial disorientation, diet, drugs, and exercise upon flight capabilities. Recognition of emotional difficulties; emotional considerations in accident prevention. Interpretation of autopsy reports.

AO 3100 Management Of Accident-Prevention Programs (3-2).
Management theories, practices, communications and controls; automatic data-processing and analysis of accident statistics; legal consideration in safety management; use of systems safety in hazard identification.

AO 3120 Technological Aspects of Accident-Prevention and Analysis (3-2).
Topics include case studies of technological design-related aviation mishaps; identification of structural failure modes; computer and simulator methods in aeronautics; safety-related problems of Navy weapons-system evaluation and acquisition.

COMMAND, CONTROL AND COMMUNICATIONS (C3) GROUP



C 3 students in their study environment

The Command, Control and Communications Academic Group has administrative responsibility for the academic content of the Command, Control and Communications program. Teaching in this program is carried out by faculty members attached to the various academic departments associated with the program.

Michael Graham Sovereign, Professor of Operations Research; Chairman (1970)*; B.S., Univ. of Illinois, 1959; M.S., Purdue Univ., 1960; Ph.D., 1965.

Alvin Francis Andrus, Associate Professor of Operations Research and Statistics (1963); B.A., Univ. of Florida, 1957; M.A., 1958.

Thomas Jay Brown, Major, U.S. Air Force; Instructor (1984); B.S. Oregon State University, 1968; M.S., Air Force Institute of Technology, 1973.

Kenneth La Vern Davidson, Associate Professor of Meteorology (1970); B.S., Univ. of Minnesota, 1962; M.S., Univ. of Michigan, 1966; Ph.D., 1970.

Allen Eugene Fuhs, Distinguished Professor of Aeronautics (1966); B.S.M.E., Univ. of New Mexico, 1951; M.S.M.E., California Institute of Technology, 1955; Ph.D., 1958.

Leon Bernard Garden, Commander, U.S. Navy; Instructor in Electrical Engineering (1981); B.S., Univ. of California at Los Angeles, 1959; M.S., Naval Postgraduate School, 1972.

Donald Paul Gaver, Jr., Professor of Operations Research and Statistics (1971); S.B., Massachusetts Institute of Technology, 1950; S.M., 1951; Ph.D. Princeton Univ., 1956.

James Kern Hartman, Associate Professor of Operations Research (1970); B.S., Massachusetts Institute of Technology, 1965; M.S., Univ. of Nebraska, 1967; Ph.D., Case Western Reserve Univ., 1970.

Wayne Philo Hughes, Jr., Captain, U.S. Navy; Chair Professor of Applied Systems Analysis (1979); B.S., U.S. Naval Academy, 1952; M.S., Naval Postgraduate School, 1964.

Carl Russell Jones, Professor of Administrative Sciences: Chairman (1965)*, B.S., Carnegie Institute of Technology, 1956; M.B.A., Univ. of Southern California, 1963; Ph.D., Claremont Graduate School, 1965.

John T. Malokas, Lieutenant Colonel, U.S. Air Force; Curricular Officer; B.S., Ohio University, 1966; M.S., Univ. of Southern California, 1973; M.S. in Systems Technology, Naval Postgraduate School, 1979.

Norman Robert Lyons, Associate Professor of Management Information Systems (1979); B.S., Stanford Univ., 1966; M.S.I.A., Carnegie-Mellon Univ., 1970; Ph.D., 1972.

Paul Henry Moose, Associate Professor of Electrical Engineering (1980); B.S., Univ. of Washington, (1960); M.S., 1966; Ph.D., 1970.

Frank Marchman Perry, Major, U.S. Army, Instructor in Operations Research (1983); B.S., U.S. Military Academy (1967); M.S., Naval Postgraduate School (1975).

Gary Kent Poock, Professor of Operations Research and Man-Machine Systems (1967); B.S., Iowa State Univ., 1961; M.S., Univ. of Miami, 1965; Ph.D., Univ. of Michigan, 1967.

Joseph S. Stewart II, Commander, U.S. Navy; Instructor in Operations Research (1984); B.S., U.S. Naval Academy, 1966; M.S., Naval Postgraduate School, 1973.

Lawrence Noel Schuetz, Captain, U.S. Navy, (1982); B.B.A., Univ. of Texas, 1960; M.A.I.R., Univ. of Southern California, 1974.

Karlheinz Edgar Woehler, Professor of Physics (1962); B.S., Univ. of Bonn, 1953; M.S., Technical Univ., Aachen, 1955; Ph.D., Univ. of Munich, 1962.

John McReynolds Wozencraft, Professor of Electrical Engineering; (1977); B.S., U.S. Military Academy, 1946; S.M. and E.E., Massachusetts Institute of Technology, 1951; Sc.D., 1957.

Al M. Zied, Technical Director, W.A.R. Lab (1983); B.S., Alexandria Univ., 1964; M.Sc., the Ohio State Univ., 1971; Ph.D., 1980.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

MASTER OF SCIENCE IN SYSTEMS TECHNOLOGY (Command, Control & Communications)

The degree of Master of Science in Systems Technology (Command, Control & Communications) will be awarded at the completion of an interdisciplinary program carried out in accordance with the following degree requirements:

a. The Master of Science in Systems Technology (Command, Control & Communications) requires a minimum of 45 quarter hours of graduate level work of which at least 15 hours must represent courses at the 4000 level.
b. In addition to the 45 hours of course credit, an acceptable thesis must be completed.
c. The program must be approved by the Chairman of the Command, Control and Communications Academic Group.

DEPARTMENTAL COURSE OFFERINGS

CC 0001 Seminar (0-1).
Special lectures and discussion of matters related to the C3 program.

CC 0810 Thesis Research (0-0).
Every student conducting thesis research will enroll in this course.

SO 0810 Thesis Research (0-0).
Every student conducting thesis research will enroll in this course.

CC 3505 C3I Architecture (4-0).
This course supports the C3, Space Operations, and Intelligence Curricula by providing an overview of the principles, concepts, and trade-offs underlying all C3I architectures. Students address alternative models of C3I architecture, and then examine the attributes of a variety of current and proposed C3I architectures. In a class project, students assess the probability that a current or proposed C3I architecture can satisfy a measure of effectiveness of their choice. PREREQUISITES: A 3000-level Operations Research survey course or permission of the instructor, TOP SECRET clearance with access to SPECIAL INTELLIGENCE information.

Graduate Courses

CC 4113 Policies and Problems in C3 (5-0).
An in-depth study of the fundamental role C3 systems fulfill in operational military situations, including crisis warning and crisis management. An analysis of the changing role of intermediate level headquarters and its impact on C3 system requirements and design. Additionally, the course considers the complexities imposed on C3 systems as the force structure becomes more heterogeneous, as in the case of NATO. Case study of selected incidents and systems. Specifically for students in the C3 curriculum. PREREQUISITES: CO 3111, NS 3064.

CC 4900 Special Topics in Command Control and Communications (2-0 to 5-0).
Supervised study in selected areas of command control and communications to meet the needs of individual students. May be repeated for credit if course content changes. PREREQUISITE: Consent of Group Chairman. *Graded on a Pass/Fail basis only.*

DEPARTMENT OF COMPUTER SCIENCE

Student at work on the Control Image Processing System in the Department of Computer Science with Professor Michael Zyda and staff member Albert Wong observing

Bruce James MacLennan, Associate Professor of Computer Science; Acting Chairman (1979)*; B.S., Florida State Univ., 1972; M.S., Purdue Univ., 1974; Ph.D., 1975.

Gordon Hoover Bradley, Professor of Computer Science (1973); B.S., Lehigh Univ., 1962; M.S., 1964; Ph.D., Northwestern Univ., 1967.

Paul William Callahan, Lieutenant Commander, U.S. Navy; Instructor in Computer Science (1983); B.S., Western Michigan Univ., 1971; M.S., Naval Postgraduate School, 1979.

Daniel Lee Davis, Associate Professor of Computer Science (1983); B.S., Georgia Institute of Technology, 1965; Ph.D., California Institute of Technology, 1969.

Robert W. Floyd, Grace Murray Hopper Research Professor of Computer Science (1985); B.A., Univ. of Chicago, 1953; B.S., 1958.

Richard Wesley Hamming, Adjunct Professor of Computer Science (1976); B.S., Univ. of Chicago, 1937; M.S., Univ. of Nebraska, 1939; Ph.D., Univ. of Illinois, 1942.

David Kai-Mei Hsiao, Professor of Computer Science (1982); B.A., Miami Univ., 1961; M.S., 1964; Ph.D., Univ. of Pennsylvania, 1968.

Alan Keith Johnson, Lieutenant Commander, U.S. Navy; Instructor in Computer Science (1983); B.A., Univ. of Texas at Austin, 1965; M.S., Naval Postgraduate School, 1975.

Robert G. Kenedy, Instructor in Computer Science (1985); B.A., Univ. of California, San Diego, 1969; M.S., Univ. of Southern California, 1975.

Uno Robert Kodres, Professor of Computer Science (1963); B.A., Wartburg College, 1954; M.S., Iowa State Univ., 1956; Ph.D., 1958.

Ronald Brent Kurth, Lieutenant Commander, U.S. Naval Reserve; Instructor in Computer Science (1983); B.S., Chico State College, 1970; M.S., Naval Postgraduate School, 1979.

Roger Marshall, Adjunct Professor of Computer Science (1984); B.S., Indian Inst. of Tech., 1968; M.S., Nova Scotia Tech. Univ., 1970; Ph.D., Univ. of Nebraska, 1974.

Bradford Douglas Mercer, Captain, U.S. Air Force; Instructor in Computer Science (1982); B.A., Univ. of Texas, 1974; M.S.S.M., Univ. of Southern California, 1980; M.S., Air Force Institute of Technology, 1982.

George Anthony Rahe, Professor of Computer Science (1965); B.S., Univ. of California at Los Angeles, 1957; M.S., 1959; Ph.D., 1965.

Ronald Ernest Rautenberg, Lieutenant Commander, U.S. Naval Reserve; Instructor in Computer Science (1984); B.S., Univ. of Washington, 1970; M.S., Naval Postgraduate School, 1980.

Linda Carranza Rawlinson, Commander, U.S. Navy; Instructor in Computer Science (1985); B.A., Univ. of California, San Diego, Revelle College, 1969; M.S., Naval Postgraduate School, 1980.

Alan Albert Ross, Lieutenant Colonel, U.S. Air Force; Assistant Professor of Computer Science (1982); B.S.E., Univ. of California at Davis, 1966; M.S.E.E., Air Force Institute of Technology, 1971; Ph.D., Univ. of California at Davis, 1978.

Neil Charles Rowe, Associate Professor of Computer Science (1983); B.S., Massachusetts Institute of Technology, 1975; M.S., 1978; Electrical Engineer, 1978; Ph.D., Stanford University, 1983.

Louis D. Stevens, Adjunct Instructor of Computer Science (1984); B.S.E.E., Texas Tech. Univ., 1948; M.S.E.E., Univ. of California at Berkeley, 1949.

Cynthia M.Walters, Adjunct Instructor of Computer Science (1983); B.S., Kansas State Univ., 1971; M.S., New Mexico State Univ., 1976.

Thomas C. Wu, Associate Professor of Computer Science (1985); B.A., San Diego State Univ., 1975; M.S., 1978; M.S., Univ. of California, San Diego, 1981; Ph.D., 1983.

Michael Joseph Zyda, Assistant Professor of Computer Science (1984); B.A., Univ. of California at San Diego, 1976; M.S., Univ. of Massachusetts at Amherst, 1978; D.Sc., Washington Univ., 1984.

**The year of joining the Postgraduate School faculty is indicated in parenthesis.*

MASTER OF SCIENCE IN COMPUTER SCIENCE

1. The degree of Master of Science in Computer Science will be awarded upon the satisfactory completion of a program, approved by the Chairman, Computer Science Department, which satisfies, as a minimum, the following degree requirements:

   a. At least 40 quarter hours of graduate-level work of which at least 12 quarter hours must be at the 4000 level.

   b. The Program shall include at least:

      28 quarter hours in Computer Science
      12 quarter hours in the other discisplines.

   c. Completion of an approved sequence of courses constituting specialization in an area of Computer Science.

d. Completion of an acceptable thesis in addition to the 40 quarter hours of course work.

DOCTOR OF PHILOSOPHY IN COMPUTER SCIENCE

The Department of Computer Science has a program leading to the degree of Doctor of Philosophy. Areas of special strength in the department are database systems, software engineering, and systems architecture. Minors in areas of other departments are possible. A noteworthy feature of these areas of research is that the candidate's research may be conducted off-campus in the candidate's sponsoring laboratory or unit of the federal government. The degree requirements are as outlined under the general school requirements for the Doctor's degree.

COMPUTING FACILITIES

The Computer Science Department provides NPS students and faculty with access to minis and micros for teaching, thesis work and research. The general computing facility includes two DEC VAX11/780 mini computers with 10 million bytes of primary memory, 1.2 billion bytes of disk space, tape drives, and line and laser printers. One VAX is running the Berkeley UNIX operating system which includes a wide variety of contemporary computer science research software. The other VAX 11/780 is running the DEC VMS operating system which includes contemporary high-quality language compilers.

In addition, The Department has a Graphics and Image Processing Facility, and a Microcomputer Laboratory. Both the facility and the laboratory are being utilized to support course work. thesis work, and research.

The Graphics and Image Processing Facility is centered around a DEC VAX 11/750 with one million bytes of primary memory and 450 million bytes of disk space. Computer graphics are supported by one or more of each type of graphics terminals (for a total of eleven) including: 3-D vector, conic vector, storage tube, color raster and plasma terminals. Image processing is supported with an EYECOM monochromatic picture digitizer and display, a Ramtek color raster display system, two Silicon Graphics IRIS workstations and a Comtal Vision One/20 system. Additionally, the Vision One/20, with its built-in LSI-11 processor, has considerable stand-alone image processing capabilities.

The Microcomputer Laboratory provides hand-on experience with contemporary microcomputer technology for students in microcomputers, real-time combat computer systems, applications of microelectronics to distributed systems, and innovative architecture designs. The Laboratory provides a test-bed facility for classroom assignments, student theses and faculty research in operating systems, multiple processor organizations, and microcomputer software development. The Laboratory contains a variety of equipment including INTELLEC-8, INTEL MDS-80, ALTOS Z80, AMD Z8000, and DEC LSI-11 systems as well as a number of single-board computers. Most of these systems are supported by floppy disks or hard disks, CRT terminals, and printers. A wide variety of peripheral devices are available for experimentation including bubble memory modules, plasma display devices, robotics testbeds, etc.

The facilities of the W.R. Church Computer Center provide timesharing and batch processing for Computer Science classroom instruction and research. The Center has an IBM 3033 Attached Processor with 16 megabytes of memory. The system has an IBM 3850 Mass Store that can hold 38 billion bytes of information. The system supports a wide variety of languages, and applications programs. Timesharing service is provided from 8 terminal/printer locations across the campus.

RESEARCH LABORATORIES

The computing equipments of the research laboratories are purchased by various research projects with external funds. They are dedicated to the NPS students and faculty for theses development and faculty research. There are eight research laboratories in the Computer Science Department. The ones with computer equipment are listed as follows:

Computer Engineering and Combat Systems Laboratory
(Intel iSBC 86/12 single-board computers, RAMs, bubble memories, disk drives, Intel's MULTIBUS and Ethernet)

Design Automation Laboratory
(Prolog microcomputer system and AED color graphic terminal)

Laboratory for Database Systems Research
(DEC PDP 11/44s, DEC's parallel communications links to VAX 11/780, printers and terminals)

Laboratory for Intelligent Workstation Research
(Sun workstations, Ethernet, printer and terminals)

Laboratory for Limited-Resource Computing
(PCs)

DEPARTMENTAL COURSE OFFERINGS

CS 0001 Seminar (0-1).
Special or guest lecturers.

CS 0002 Seminar (0-1).
This seminar is open to new students only. It is lectured by the Chairman of the Department and offered every Fall and Spring.

CS 0810 Thesis Research (0-0).
Every student conducting thesis research will enroll in this course.

Upper Division Courses

CS 2010 Introduction to Computers and Data Processing for Non-computer Science Majors (2-0).
An introduction to the general characteristics of contemporary computers and to the functions they serve in a diversity of organizations is provided. The capabilities and limitations of computing as well as the economics of data processing in general are emphasized. There are no prerequisite or corequisite courses. Prior computing experience is not assumed and programming is not taught.

CS 2106 Introduction to Programming in FORTRAN (1-2).
The course is an introduction to programming using FORTRAN. The course is intended for management students with no previous programming experience who are already familiar with computer fundamentals. PREREQUISITE: CS 2010 or consent of Instructor. *Graded on Pass/Fail basis only.*

CS 2850 PL/1 Programming Laboratory (0-2).
Introduction to programming in Pl/1 for students with previous experience with computer problem solving with structured programming in a high order computer language. Computer projects of increasing difficulty are assigned. PREREQUISITES: CS 2950 or CS2970. *Graded on Pass/Fail basis only.*

CS 2950 Structured Programming with FORTRAN (5-0).
An introduction to computer algorithms, programs and hardware. Algorithms and programs are developed using a structured approach to stepwise refinement of the algorithms and programs. The design and testing of computer programs in FORTRAN are studied, and practiced by the student in the laboratory. Computer projects of increasing difficulty are assigned. Computer systems including data representation, computer organization, and systems software are introduced.

CS 2960 Structured Programming with PL/I (5-0).
An introduction to computer algorithms programs and hardware. Algorithms and programs are developed using a structured approach to stepwise refinement of the algorithms and programs. The design and testing of computer programs in PL/I are stud-

ied, and practiced by the student in the laboratory. Computer projects of increasing difficulty are assigned. Computer systems including data representation, computer organization, and systems software are introduced.

CS 2970 Structured Programming with PASCAL (5-0).
An introduction to computer algorithms programs and hardware. Algorithms and programs are developed using a structured approach to stepwise refinement of the algorithms and programs. The design and testing of computer programs in PASCAL are studied, and practiced by the student in the laboratory. Computer projects of increasing difficulty are assigned. Computer systems including data representation, computer organization, and systems software are introduced.

Upper Division or Graduate Courses

CS 3010 Computing Devices and Systems (4-0).
Designed primarily for non-computer science majors, this course examines functional components and their organization as a computer system. Although emphasis is upon computer hardware, the importance of both hardware and software in constituting a computer system is discussed. Important instances of software-hardware trade-offs in the implementation of various components are discussed. In this course, computer systems are examined through a hierarchy of four levels: The electronic circuit level, the logic or digital device level, the programming level, and the systems level. Major emphasis is upon the higher levels (programming and systems). PREREQUISITE: CS 2950 or CS 2960 or CS 2970 or consent of Instructor.

CS 3020 Software Design (3-2).
This course will provide the student with a broad background in the concept, design and development of computer programs. Language selection, program semantics, testing and debugging, and program efficiency and documentation are some of the topics that will be covered in the course. The laboratory sessions will be devoted to assigned readings, programming projects and the writing of a term paper on a topic of current interest in software engineering. PREREQUISITES: CS 2810 and CS 2812.

CS 3030 Operating Systems Structures (4-0).
Designed primarily for non-computer science majors, this course will provide a broad overview of operating systems including memory management techniques, job scheduling, processor scheduling, device management and data (information) management techniques. Case studies will be included to illustrate the issues in manager-operating system interfaces, operating system selection, data control and security, and operating system utility support. In addition, future trends in computers will be identified, including maxi, mini, and microcomputers. PREREQUISITES: CS 3010 or equivalent background and consent of Instructor.

CS 3111 Principles of Programming Languages (4-0).
This course is an introduction to the design, evaluation and implementation of programming languages. The four themes of name, data, control, and syntactic structuring are traced through the five major programming language generations. Principles for the evaluation of languages are developed and investigated. Key implementation concepts are covered, including interpreters and runtime organization. PREREQUISITES: CS 2950 or CS 2960 or CS 2970 or consent of Instructor.

CS 3113 Introduction to Compiler Writing (3-2).
This course is intended to explore the basics of modern compiler design and construction techniques. The fundamentals of scanning, parsing and compiler semantics are developed in the framework of modern compiler-compiler and translator-writing system technology. The laboratory periods will be used to develop a small model compiler/assembler. PREREQUISITES: CS 3111 and CS 3300 or consent of instructor.

CS 3200 Introduction to Computer Organization (3-2).
This course examines the organization of computers, processor architectures, machine and assembly language programming. Microcomputer systems are used in the laboratory to give students hands-on experience. Included are hardware components: the processor, memories, serial I/O, parallel I/O, real time clock, interrupt control, DMA; processor instructions: information transfer, arithmetic, control, process switching; machine language and assembly language programming: arithmetic functions, input/output, interrupt handling, multicomputer control. PREREQUISITES: CS 2970 and either EE 2810 or EE 2225.

CS 3201 Introduction to Computer Architecture (3-2).
Designed primarily for weapons and electronic warfare majors, this course examines the organization of computers, processor architecture, machine and assembly language programming. The INTEL 8080A systems are used in the laboratory to give students hands-on experience. Included are hardware components: the processor, memories, serieal I/O, parallel I/O, real time clock, interrupt control, DMA; processor instructions: information transfer, arithmetic, control, machine language and assembly language programming: arithmetic functions, input/output, interrupt handling. PREREQUISITES: CS 2950 or CS 2960 and EE 2810 or equivalent.

CS 3250 Information and Decision Systems (3-2).
This course investigates computer-based information and decision systems designed to provide the human user with efficient information management tools and with methods for individual and group decision-making. The student will perform exercises on a number of graphics terminals. A major design project in computer-based information and decision aids is required. PREREQUISITE: CS 2950 or CS 2960 or CS 2970 or consent of Instructor.

CS 3300 Data Structures (3-1).
The course deals with the specification, implementation and analysis of data structures. Common data objects such as strings, arrays, records, linear lists, lists and trees, together with the operations used to manipulate these objects are studied. Particular emphasis is placed on linked structures. Implementation of symbol tables by hash tables and other means is presented. Applications to memory management, compiler design and sorting/searching algorithms are given. Computer projects in a high-level language are required. PREREQUISITES: CS 2970 or consent of Instructor.

CS 3310 Artificial Intelligence (4-0).
Survey of topics and methods of Artificial Intelligence. Topics include simple learning tasks, visual scene analysis and descriptions, understanding of natural language, computer game playing, knowledge engineering systems. Methods include heuristic search and exploitation of natural constraints, means-ends analysis, production systems, semantic networks, and frames. Emphasis is placed on solving problems which seem to require intelligence rather than attempting to stimulate or study natural intelligence. Class and individual projects to illustrate basic concepts are assigned. PREREQUISITE: MA 0125 or MA 2025 or consent of Instructor.

CS 3400 Comparative Computer Architecture (4-0).
This course examines the fundamental concepts of computer architectural design. A definition of computer architecture and organization, the history and evolution of computers, and architectural descriptive languages are presented. Initially, the designs of functional architectural components, to include ALU's, control units, memory hierarchies and input-output organizations, are examined. Important instances of software-hardware tradeoffs in such designs are discussed. Basic approaches to enhancing computer performance are discussed. Representative computer class architectures are examined and compared. PREREQUISITE: CS 3200 or CS 3201 or consent of Instructor.

CS 3450 Software System Design (3-1).
This course covers the design and implementation of software system elements, including assemblers, loaders, input/output control sub-systems, and interpreters. PREREQUISITES: CS 3200, CS 3300 and CS 3111 or consent of Instructor.

CS 3460 Software Methodology (3-2).
This course is intended for students majoring in Computer Science. Topics covered in the course include program semantics, program decomposition, information hiding, software reliability and testing, informal verification and correctness of programs, elementary software engineering techniques and program efficiency and metrics. The laboratory sessions will be devoted to developing a significant piece of software and assigned readings from the software literature. Knowledge of one or more programming languages and data structures is assumed.

CS 3502 Computer Communications and Networks (4-0).
An introduction to the structure and architecture of computer networks. Topics covered include network topology, single and multiple server queueing models, link establishment and link operation protocols, local area networks, packet radio networks, and point-to-point networks. The ISO model and the ARPA, ALOHA and ETHERNET systems are studied. Term papers and/or

projects will be an important aspect of the course. PREREQUISITES: CS 2810 and CS 3010 (or equivalent) and MA 2300 (or equivalent).

CS 3550 Computers in Combat Systems (3-2).
This course describes the functions and algorithms of combat systems, the human interaction, and the systems organization in terms of processes. The laboratory experience includes work with navigational, tracking and ballistics functions, display control and the use of wakeup and block primitives in process control. Real-time performance analysis and prediction using simulations is included. PREREQUISITE: CS 3200 or CS 3201 or equivalent.

CS 3601 Automata, Formal Languages and Computability (4-0).
This course will cover the Chomsky hierarchy of Formal Languages (regular sets, context-free languages, context-sensitive languages, and recursively enumerable languages) and the types of grammars and automata associated with each class in the hierarchy. Emphasis is placed on Turing machines and decidability questions. Computational intractability and the P=NP question will be covered. PREREQUISITIES: MA 2025 and MA 3026 or equivalent.

CS 3650 Design and Analysis of Algorithms (4-0).
This course focuses on the design and analysis of efficient algorithms. Techniques for analyzing algorithms in order to measure their efficiency are presented. Control structure abstractions, such as divide and conquer, greedy, dynamic programming, backtrack (branch and bound), and local search methods, are studied. The theory of NP-completeness is presented along with current approaches to NP-hard problems. PREREQUISITE: CS 3300 and CS 3601.

CS 3800 Directed Study in Computer Sciences (0-2 to 0-8).
Individual research and study by the student under the supervision of a member of the faculty. Intended primarily to permit interested students to pursue in depth subjects not fully covered in formal class work. A written report to the chairman is required at the end of the quarter. PREREQUISITE: Consent of Instructor. *Graded on Pass/Fail basis only.*

CS 3900 Selected Topics in Computer Science (3-0).
Presentation of a wide selection of topics from current literature. Lectures on subjects of current interest and exploration may be presented by invited guests from other universities, government laboratories, and from industry, as well as by faculty members of the Naval Postgraduate School. Tours of other facilities of interest may also be conducted. PREREQUISITE: Consent of Instructor. *Graded on Pass/Fail basis only.*

Graduate Courses

CS 4112 Operating Systems (4-0).
An in-depth theoretical treatment of operating systems concepts. Major course topics include process synchronization using semaphores, critical regions, and rendezvous, virtural memory including demand paging and segmentation, dynamic linking and loading, file structures and information security. The producer-consumer problem, readers and writers problem and the dining philosophers problem are examined. Architectural and language implications of evolving operating systems are considered. PREREQUISITES: CS 3200 and either CS 3112 or CS 3030.

CS 4113 Advanced Language Topics (4-0).
This course covers advanced topics and recent developments in programming languages and compilers. Three major topics are functional programming, object-oriented programming and logic programming. Both the theory and practice of functional programming are covered. Theoretical topics include the Church-Rosser theorem, the significance of various evaluation orders, and the use of recursive simultaneous equations to define data types. Functional, object-oriented and logic programming are viewed from the unified perspective of tree transformations. PREREQUISITES: CS 3111 and CS 3450 or consent of Instructor.

CS 4150 Programming Tools and Environment (4-0).
This course covers the design and implementation of tools to aid software development, including syntax-directed editors, version-control systems, language-oriented debuggers, symbolic execution vehicles, programming databases, macroprocessors, and automatic programming tools. These topics are discussed in the context of an integrated, language-oriented programming environment. PREREQUISITES: CS 3450 and CS 4113 or consent of Instructor.

CS 4202 Computer Graphics (3-2).
An introduction to the principles of the hardware and the software used in the production of computer generated images. The focus of the course is a major design project utilizing the departmental computer graphics and image-processing facilities. The course is intended for students proficient in the development of software systems. PREREQUISITE: CS 2970, CS 3200, CS 3300 or consent of the Instructor.

CS 4203 Interactive Computation Systems (3-2).
A study of the human-computer interface and methods for interactive computer-assisted problem solving. Topics include applicable human psychology, physiology and cognitive science. The main focus of the course is a design project involving computer graphics. PREREQUISITE: CS 4202 or consent of the instructor.

CS 4300 Data Base Systems (4-0).
This course presents an up-to-date exposition of data base systems. The course deals with data base system architectures, physical storage organization, data models, data languages, design theory for relational data bases, query optimization, data base integrity, security, concurrency control and recovery. Also, several commercial data base systems (e.g. IMS) are reviewed. PREREQUISITES: CS 3450 and CS 3300, or consent of Instructor.

CS 4310 Advanced Artificial Intelligence (4-0).
Artificial intelligence has seen a rapid growth in applications in recent years. This course will survey a wide variety of current research, using a seminar format. Application areas surveyed include planning, language understanding, vision, robotics, machine learning, human tutoring, database design, and statistics. PREREQUISITES: CS 3310 or consent of Instructor.

CS 4311 Knowledge Based Systems (3-1).
This course covers the design and implementation of knowledge-based systems. Topics include acquiring, representing, and organizing knowledge, multiple levels of problem structure and domain knowledge, metaknowledge and multilevel control structures. These topics will be studied in the contest of several problem-solving, signal understanding, and natural language understanding tasks. PREREQUISITES: CS 3310 and CS 3450 or consent of Instructor.

CS 4320 Data Base System Design (4-0).
Primarily designed for non-computer science majors, this course explores the design and technology of data base software. Implementation techniques, viable alternatives, data base philosophy data manipulation in complex information environments, and system requirements are explored. Examples of systems will be drawn from active DOD data base systems and current application/research in the private as well as public sectors. PREREQUISITE: CS 3020 or knowledge of a higher-level language and consent of Instructor.

CS 4322 Advanced Database Systems Topics (3-1).
This course covers advanced topics and recent developments in database systems and machines. Three major topics are multi-lingual database systems, multi-backend data base systems and database machines. In addition to theoretical and design studies, the experimentation of some advanced prototype database systems will be included. PREREQUISITES: CS 3450 and CS 3300, or CS 4300, or consent of Instructor.

CS 4400 Computer System Performance Evaluation (3-2).
The performance of computer systems — hardware, software, and the users — is the focus of this course. Specific tools used in performance evaluation including analytic modeling, control system modeling, simulation, software monitoring, and hardware monitoring are discussed. The role of performance evaluation in system design and total system life-cycle development is examined in a seminar-like environment. PREREQUISITES: MA 3026, CS 3400, CS 3450 or consent of Instructor.

CS 4450 Advanced Computer Architecture (4-0).
This course covers advanced topics in computer architecture and the application of concepts in computer architecture to the design and use of computers. The topics discussed include classes of computer architecture, language directed architecture, application oriented architecture and high performance architecture. PREREQUISITES: CS 3400 or EE 3822.

CS 4451 Design and Analysis of Multiple-Processor, Real-Time Computers (3-1).
This course covers computer architectures ranging from pure multiprocessor to massively parallel systems used for real-time

applications. Processing capacities are analyzed and performance estimates are made based on various real-time applications. Reliability and fault-tolerance issues are considered for the multiple-processor systems. Application-program complexities are considered from the programmer's point of view. Laboratory experiments with multiple processor systems will be conducted in the microcomputer laboratory. PREREQUISITES: CS 3200 and CS 3450 or consent of Instructor.

CS 4461 Microprogramming - Design and Implementation (3-2).
This course will cover the principles and concepts of microprogramming and the design of bit-slice computers and controllers. The course has two aspects, the design of digital systems around microprogrammable ICs, and the production of new microcodes for previously designed systems. The student will investigate the techniques and tools which are applicable to both of these aspects. The emphasis will be on military applications of microprogramming, and on direct implementations of problem solutions, rather than on the design of general-purpose architectures or instruction sets. PREREQUISITES: CS 3400 or EE 3800 or consent of Instructor.

CS 4470 Advanced Computer Graphics Topics (3-2).
This course covers advanced topics in computer image generation. The topics discussed include quality and realism in computer images, advanced real-time interactive systems, and special architectures for the real-time generation and display of computer images. PREREQUISITE: CS 4202, CS 4203 and the consent of the Instructor.

CS 4500 Software Engineering (3-2).
The techniques for design, development, and management of large scale software systems/projects is the focal theme of this course. Specific topics to be covered include: the nature of software development: software specification and the use of formal specification tools. Software coding: programming methodology, language support, and program maintenance. Software evaluation: performance prediction, validation, testing, and verification. PREREQUISITE: CS 3460 or CS 3020 or consent of Instructor.

CS 4510 Cognitive Sciences and Computer Programming (3-0).
This is a seminar on the application of results in the cognitive sciences to the study of computer programming. There will be extensive readings covering topics in cognitive psychology, software psychology, selected areas of artificial intelligence and programming methodology. Topics covered include definition of the programming task, complexity of programs, understanding of software, and tentative models of the programming task. PREREQUISITE: CS 4500 and the consent of the instructor.

CS 4550 Distributed Computing (4-0).
The course covers all aspects of computer systems that have multiple computers connected by communications links. Distributed systems architectures, local area networks, geographically distributed network, multiprocessor systems, performance and reliability, distributed operating systems and distributed database systems are studied. The course also covers distributed computing related topics in the areas of programming languages, computer science theory and software engineering. PREREQUISITES: CS 3112 and CS 3400.

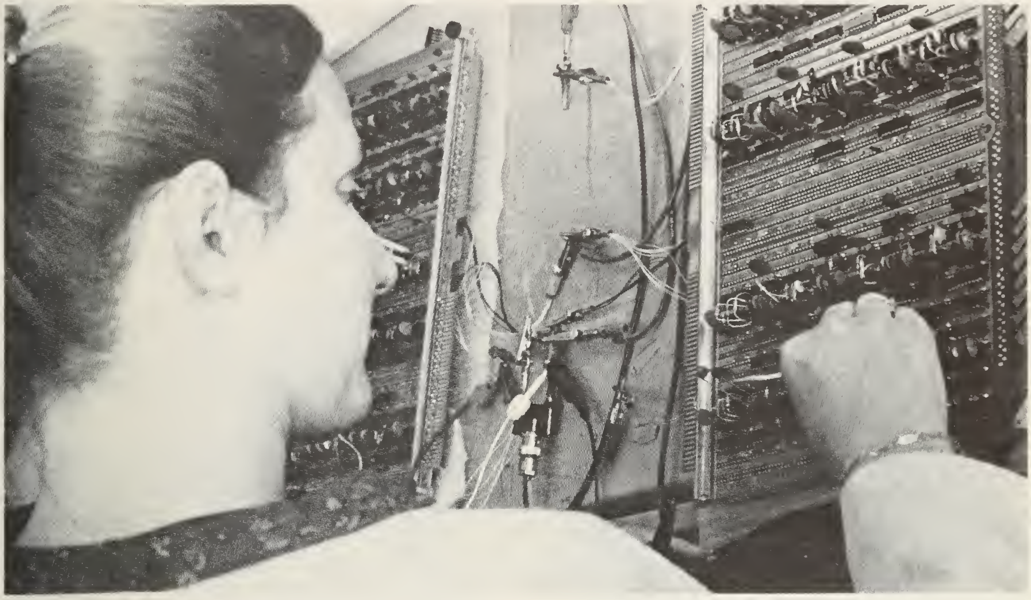
CS 4700 Epistemology for Computer Scientists (3-0).
This is a seminar on the applications of epistemology, the theory of knowledge, to computer science problems. There will be a particular emphasis on Artificial Intelligence applications, especially knowledge representation. The course covers the major epistemological theories from Plato to the present, emphasizing those with a relevance to computer science. Other topics discussed include logic (deductive and inductive), philosophy of science, foundations of mathedmatics and the use of empirical techniques in computer science. PREREQUISITES: CS 3310 and consent of Instructor; CS 4310 or CS 4311 is also recommended.

CS 4800 Directed Study in Advanced Computer Science (0-2 to 0-8).
Directed advanced study in computer science on a subject of mutual interest to student and staff member. Intended primarily to permit students to pursue in depth subjects not fully covered in formal class work or thesis research. May be repeated for credit with a different topic. A written report to the department chairman is required at the end of the quarter. PREREQUISITE: Consent of Instructor. *Graded on Pass/Fail basis only.*

CS 4900 Research Seminar in Computer Science (2-0).
This course will examine the current and planned research of Computer Science faculty in multiple fields of study. The course is designed to support Computer Science students in their fourth quarter of study in the selection of an area/topic of thesis research. PREREQUISITE: Computer Science students in fourth quarter or consent of department Chairman. *Graded on Pass/Fail basis only.*

CS 4910 Advanced Readings in Computer Science (0-2 to 0-8).
Directed readings in computer science on a subject of mutual interest to student and faculty member. The course allows in-depth study of advanced topics not fully covered in formal class work or thesis research. May be repeated for credit with a different topic. A written report to the chairman is required at the end of the quarter. PREREQUISITE: Consent of Instructor.

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING



Student shown testing design of an experimental digital transmitter

Harriett B. Rigas, Professor; Chairman (1984)*; B.S. Queens University, Ontario, Canada; M.S., University of Kansas, 1959; Ph.D., University of Kansas, 1963.

Larry Wayne Abbott, Assistant Professor (1984); B.S.E.E., Univ. of California at Berkeley, 1969; M.S., Univ. of Southern California, 1976; M.S. Eng., California State Univ. at Northridge, 1980; D. Eng., Univ. of Kansas, 1984.

John Miller Bouldry, Associate Pro- (1946); B.S., Northeastern Univ., 1941; M.S., Brown Univ., 1956.

Stephen Breida, Associate Professor (1958); B.S.E.E., Drexel Institute of Technology, 1952; M.S.E.E., Purdue Univ., 1954.

Daniel Bukofzer, Assistant Professor (1980); B.S.E.E., California State Univ. at Los Angeles, 1970; M.S.E.E., Univ. of California at Los Angeles, 1972; Ph.D., Univ. of California at Davis, 1979.

Thomas Jay Brown, Major, U.S. Air Force; Instructor (1984); B.S., Oregon State University, 1968; M.S., Air Force Institute of Technology, 1973.

Jon T. Butler, NAVELEX Chair Professor (1985); B.S.E.E., Rensselaer Polytechnic Institute, 1966; M. Eng., Rensselaer Polytechnic Institute, 1967; Ph.D., Ohio State Univ., 1973.

Jin-Fu Chang, Associate Professor (1984), B.S., National Taiwan Univ., 1970; Ph.D., Univ. of California at Berkeley, 1977.

Mitchell Lavette Cotton, Associate Professor of (1953); B.S., California Institute of Technology, 1948; M.S., Washington Univ., 1952; E.E., Univ. of California at Berkeley, 1954.

John Henry Duffin, Professor (1962); B.S., Lehigh Univ., 1940; Ph.D., Univ. of California at Berkeley, 1959.

Gerald Dean Ewing, Associate Professor (1963); B.S.E.E., Univ. of California at Berkeley, 1957; M.S.E.E., 1959; E.E. Oregon State Univ., 1962; Ph.D., 1964.

Alex Gerba, Jr., Associate Professor (1959); B.E.E., Univ. of Louisville, 1947; M.S., Univ. of Illinois, 1957.

Stephen Jauregui, Jr., Adjunct Professor (1971); B.A., Univ. of California at Berkeley, 1956; M.S., Naval Postgraduate School, 1960; Ph.D., 1962.

Donald Evan Kirk, Professor (1965)*; B.S., Worcester Polytechnic Institute, 1959; M.S., Naval Postgraduate School, 1961; Ph.D., Univ. of Illinois, 1965.

Jeffrey Bruce Knorr, Professor (1970); B.S., Pennsylvania State Univ., 1963; M.S., 1964; Ph.D., Cornell Univ., 1970.

Chin-Hwa Lee, Associate Professor (1982); B.S., Nat'l Chiao-Tung Univ., 1969; M.S., Univ. of California at Santa Barbara, 1972; Ph.D., 1975.

Hung-Mou Lee, Assistant Professor (1982); B.S., National Chiao-Tung University, 1971; M.A., Harvard, 1975; Ph.D., Harvard 1981.

Paul Henry Moose, Associate Professor (1980); B.S., Univ. of Washington, (1960); M.S., 1966; Ph.D., 1970.

Michael Allen Morgan, Associate Professor (1979); B.S.E.E., California State Polytechnic Univ. at Pomona, 1971; M.S., Univ. of California at Berkeley, 1973; Ph.D., 1976.

Glen Allen Myers, Associate Professor (1965); B.S.E.E., Univ. of North Dakota, 1955; M.S.E.E., Stanford Univ., 1956; Ph.D., 1965.

Rudolf Panholzer, Professor (1964); Dipl. Ing., Technische Hochschule in Graz, Austria, 1953; D.Sc., 1961; M.S.E.E., Stanford Univ., 1956.

Sydney Richard Parker, Professor (1966); B.E.E., City College of New York, 1944; M.S., Stevens Institute of Technology, 1948; Sc.D., 1964.

John Patrick Powers, Professor (1970); B.S.E.E., Tufts Univ., 1965; M.S., Stanford Univ., 1966; Ph.D., Univ. of California at Santa Barbara, 1970.

Robert Denney Strum, Professor (1958); B.S., Rose Polytechnic Institute, 1946; M.S., Univ. of Santa Clara, 1964.

Tien-Fan Tao, Professor (1971); B.S., National Taiwan Univ., 1955; M.S., Univ. of Pennsylvania, 1958; Ph.D., Harvard Univ., 1963.

George Julius Thaler, Distinguished Professor (1951); B.E., Johns Hopkins Univ., 1940; D. Eng., 1947.

Harold Arthur Titus, Professor (1962); B.S., Kansas Univ., 1952; M.S., Stanford Univ., 1957; Ph.D., 1962.

Charles William Therrien, Associate Professor (1984), S.B. and S.M., Massachusetts Institute of Technology, 1965; Ph.D., 1969.

John Robert Ward, Professor (1962); B.Sc., Univ. of Sydney, 1949; B.E., 1952; Ph.D., 1958.

Lonnie Allen Wilson, Associate Professor(1979); B.S.E.E., Walla Walla College, 1965; M.S. Univ. of California at Los Angeles, 1969; Ph.D., 1973.

John McReynolds Wozencraft, Professor (1977); B.S., U.S. Military Academy, 1946; M.S., Massachusetts Institute of Technology, 1951; E.E., 1951; Ph.D., 1957.

Lawrence James Ziomek, Assistant Professor (1982); B.E., Villanova Univ., 1971; M.S., Univ. of Rhode Island, 1974; Ph.D., Pennsylvania State Univ., 1981.

Emeritus Faculty

William Malcolm Bauer, Professor Emeritus (1946); B.S., Northwestern Univ., 1927; E.E., 1928; M.S. Harvard Univ., 1929; D.Sc., 1940.

Jesse Gerald Chaney, Professor Emeritus (1944); A.B., Southwestern Univ., 1924; A.M., Univ. of Texas, 1930.

Paul Eugene Cooper, Professor Emeritus (1946); B.S., Univ. of Texas, 1937; M.S., 1939.

George Robert Giet, Distinguished Professor Emeritus (1925); A.B., Columbia Univ., 1921; E. E., 1923.

David Boysen Hoisington, Professor Emeritus (1947); B.S., Massachusetts Institute of Technology, 1940; M.S., Univ. of Pennsylvania, 1941.

Raymond Kenneth Houston, Professor Emeritus (1946); B.S., Worcester Polytechnic Institute, 1938; M.S., 1939.

Clarence Frederick Klamm, Jr., Professor Emeritus (1951); B.S., Washington Univ., 1943; M.S., 1948.

Robert Lee Miller, Professor Emeritus (1946); B.Ed., Illinois State Normal Univ., 1936; M.S., Univ. of Illinois, 1941.

Raymond Patrick Murray, Associate Professor Emeritus (1947); B.S., Kansas State College, 1937; M.S., Brown Univ., 1953.

Herbert LeRoy Myers, Assistant Professor Emeritus (1951); B.S., Univ. of Southern California, 1951.

Charles Benjamin Oler, Professor Emeritus (1946); B.S., Univ. of Pennsylvania, 1927; M.S., 1930; D.Eng., Johns Hopkins Univ., 1950.

Charles Harry Rothauge, Professor Emeritus (1949); B.E., Johns Hopkins Univ., 1940; D.Eng., 1949.

William Conley Smith, Professor Emeritus (1946); B.S., Ohio Univ., 1935; M.S., 1939.

Abraham Sheingold, Distinguished Professor Emeritus (1946); B.S., College of the City of New York, 1936; M.S., 1937.

Donald Alan Stentz, Associate Professor Emeritus (1949); B.S., Duke Univ., 1949; M.S., Naval Postgraduate School, 1958.

John Benjamin Turner, Jr., Associate Professor Emeritus (1955); B.S., Univ. of Arkansas, 1941; M.S., Univ. of California at Berkeley, 1948.

Allen Edgar Vivell, Dean Emeritus (1945); B.E., Johns Hopkins Univ., 1927; D.Eng., 1937.

Milton Ludell Wilcox, Associate Professor Emeritus (1958); B.S., Michigan State Univ., 1938, M.S., Univ. of Notre Dame, 1956.

** The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL DEGREE REQUIREMENTS

In addition to meeting the minimum specific academic requirement for these degrees as given below, candidates must also satisfy the general degree requirements as determined by the Academic Council.

MASTER OF SCIENCE IN ELECTRICAL ENGINEERING

1. A Bachelor of Science in Electrical Engineering or its equivalent is required. Credits earned at the Naval Postgraduate School and credits from the validation of appropriate courses at other institutions are combined to achieve the degree equivalence.

2. To complete the course requirements for the Master's Degree a student needs a minimum of 40 credits in the course sequence 3000 - 4999 of which at least 30 credits must be in Electrical and Computer Engineering. Specific courses may be required by the Department and at least four courses, which total a minimum of 12 credits, must be in the course sequence 4000-4999.

3. An acceptable thesis must be presented and approved by the Department.

MASTER OF SCIENCE IN ENGINEERING SCIENCE

Students with acceptable academic backgrounds may enter a program leading to the degree Master of Science in Engineering Science. The program of each student seeking this degree is to include at least 36 credit hours in the course sequence 3000 - 4999 in the disciplines of engineering, science, and mathematics. At least 12 of these 36 hours must be at the 4000 level, and at least 20 hours are to be in electrical engineering courses. A minimum of 8 quarter hours in 4000-level electrical engineering courses and at least 12 credit hours in courses outside of the Electrical and Computer Engineering Department are required. All students must submit an acceptable thesis. This program provides depth and diversity through specially arranged course sequences to meet the needs of the Navy and the interests of the individual. The Department Chairman's approval is required for all programs leading to this degree.

ELECTRICAL ENGINEER

1. Students with acceptable academic backgrounds may enter a program leading to the degree Electrical Engineer.

2. A minimum of 80 graduate course credits is required for the award of the Engineer's degree. Of these at least 30 hours are to be in courses in the sequence 4000-4999. An acceptable thesis must be completed. A departmental advisor will be appointed for consultation in the development of a program of study. Approval of all programs must be obtained from the Chairman of the Department of Electrical and Computer Engineering.

DOCTOR OF PHILOSOPHY

The Department of Electrical and Computer Engineering has an active program leading to the degree of Doctor of Philosophy. Areas of special strength in the department are signal processing communications systems, electronic systems, control theory and computer engineering. Joint programs with other departments are possible. A noteworthy feature of these programs is that the student's research may be conducted away from the Naval Postgraduate School in a cooperating laboratory or other installation of the federal government. The degree requirements are as outlined under the general school requirements for the Doctor's degree.

DEPARTMENTAL LABORATORIES

The Electrical and Computer Engineering Department Laboratories have excellent facilities in almost all phases of modern electrical engineering. These laboratories support classroom instruction and research and are divided into four areas: (1) Devices, Circuits, and Control Systems; (2) Electronic Systems and Signal Processing; ;(3) Microwave Devices and Antennas; and (4) Computer Engineering.

The Devices, Circuits, and Control Systems area includes the following laboratory facilities: Control Systems, Electronic Circuits, Electrical Machinery, Digital Systems and Optical Electronics. The Electronic Systems and Signal Processing area includes Radar and Electronic Warfare, Satellite Communications, Electro-Optical Image Processing, Target Classification, Sonar, Signal Processing, Communications and Speech Processing. The Microwave Devices and Antennas area includes Microwave and Antenna laboratory facilities. The Computer Engineering facilities include a VAX 11/785, work stations for VLSI design, image analysis stations, an HP-64000 microprocessor development system with 6 stations, a microcomputer laboratory which includes a variety of systems. The Department also makes extensive use of the central computer facility (IBM 3033). Status as a naval facility enables the Department to utilize Navy systems in many of the laboratories. The Department also has extensive service facilities which include the Electronic Instrument Repair and Calibration Laboratory, the Printed Circuit Etching Facility, the Equipment "Pool" and the Electronic Component Issue Room. In addition, there are also research spaces available for thesis students to conduct their research problems on an individual basis.

The Department also has outstanding computer resources that support a wide range of instructional activities and research.

DEPARTMENTAL COURSE OFFERINGS

COURSES FOR ENGINEERING AND SCIENCE CURRICULA

EC 0810 Thesis Research (0-0).
Every student conducting thesis research will enroll in this course.

EC 0950 Seminar (0-1).
Lectures on subjects of current interest will be presented by invited guests from other universities, government laboratories, and from industry, as well as by faculty members of the Naval Postgraduate School.

Upper Division Courses

EC 2100 Circuit Analysis I (3-2).
An introductory course for students with little or no electrical engineering background. The fundamental concepts of voltage, current, power, signals, and sources are developed and applied to the analysis of resistive circuits, including simple transistor amplifiers and the operational amplifier. The principle of superposition, the one-port equivalents due to Thevenin and Norton, and the source transformation theorem are introduced. PREREQUISITE: Linear algebra and calculus (may be concurrent).

EC 2110 Circuit Analysis II (3-2).
A continuation of 2101. Following the introduction of the energy-storage elements, dynamic circuits are analyzed with the aid of the Laplace transform. Network functions and other s-domain concepts are developed. Then the special case of the sinusoidal steady-state is examined, using phasor methods of analysis. Frequency response, filtering, and ac power are discussed. PREREQUISITE: 2100.

EC 2150 Review of Circuit Analysis (4-2).
A review of circuit analysis for students with a moderate background in electrical engineering. Starting from a review of the basic concepts of current, voltage, power, signals, and sources, the methods of dynamic circuit analysis are developed through the s- and

$j\omega$ domains. Network functions, frequency response, and ac power are included, as are the more common circuit theorems. PREREQUISITE: Some background in circuit analysis.

EC 2170 Introduction to Electrical Engineering (4-2).
An introductory course intended for students not majoring in electrical engineering. Circuit elements, signals and waveforms; power and energy; Kirchhoff's laws and resistive circuits; diode circuit applications; application of Laplace transform to the step and sinusoidal response of dynamic networks. PREREQUISITES: Linear algebra and calculus (may be concurrent).

EC 2200 Electronics Engineering I (3-3).
An introduction to electronic devices and ciruits. Electronic properties and charge-flow mechanisms of crystalline semiconductor material; properties of p-n junctions in diodes and bipolar junction transistors; static and dynamic models for these devices; applications of diodes in wave shaping and power supplies; application of transistors in amplifiers and digital systems; characteristics and fabrication of integrated circuits. PREREQUISITE: A first course in electrical engineering.

EC 2210 Electronics Engineering II (3-2).
Characteristics of discrete device amplifiers and operational amplifiers (OP-AMPS). Analysis and design of amplifiers including frequency response and biasing considerations. Applications of feedback amplifiers and OP-AMPS. PREREQUISITE: 2200.

EC 2220 Applied Electronics (2-4).
A project course covering the application of linear and communications integrated circuits (ICs). Coverage includes an introductory overview of important linear and communications ICs and practical experimental applications of these devices. PREREQUISITES: 2210 and 2500.

EC 2250 Accelerated Review of Electronics Engineering (4-2).
An advanced review of semiconductor devices and circuits intended for students who have previously studied the subject matter of 2200 and 2210. PREREQUISITE: Sufficient background in electronic circuits. *Graded on Pass/Fail basis only.*

EC2300 Control Systems (3-2).
The application of feedback principles to the design of linear control systems using frequency domain (Bode-Nichols), s-domain (root locus) and state variable methods. Performance criteria including steady-state accuracy, transient response specifications, bandwidth and integral performance indices are presented. Laboratory work includes testing and evaluation of physical systems and simulation studies. PREREQUISITE: 2420.

EC 2370 Electromechanical Energy Conversion (3-2).
Concepts of force and torque developed as results of the interaction of magnetic fields are presented as the common basis for all electromechanical machinery. Fundamental characteristics of DC motors and generators, synchronous machines and induction motors are developed and applied. Transformers and control and distribution circuits are also introduced. PREREQUISITE: A course in electric circuits.

EC 2400 Discrete Systems (3-0).
Principles of discrete systems, including modeling, analysis and design. Topics include difference equations, z-transforms, stability, frequency response and system diagrams.

EC 2410 Fourier Analysis of Signals and Systems (3-0).
Analysis of analog signals in the time and frequency domains; properties and applications of Fourier series and transform; convolution; laboratory work includes use of a spectrum analyzer. PREREQUISITES: Differential equations and a course in electric circuits.

EC 2420 Linear Systems (3-0).
Formulation of system models including state equations, transfer functions and system diagrams; computer and analytical solution of system equations; stability. PREREQUISITES: Laplace transform, differential equations, FORTRAN and a course in electric circuits.

EC 2450 Accelerated Review of Systems (4-2).
An advanced review of continuous-time and discrete-system theory intended for students who have pervious education in these areas. Topics covered by each student will depend upon background and competence in the

subject matter of 2400, 2410 and 2420. Some parts of the course will be in the self-study mode. PREREQUISITE: Sufficient background in linear system theory. *Graded on Pass/Fail basis only (Parts of this course may be taken through Continuing Education as mini courses EE-2151-55).*

EC 2500 Communications Theory (4-2).
In this first course on the transmission of electrical signals, the following concepts are formulated mathematically and then considered in terms of devices and systems: sampling, pulse coding; amplitude, phase, and frequency modulation; time and frequency multiplexing. Basic radio ranging and communications systems are developed and link calculations are made. PREREQUISITES: 2410 and 2210.

EC 2600 Introduction to Fields and Waves (4-0).
Static field theory is developed and applied to boundary value problems. Time-varying Maxwell equations are developed and solutions to the wave equations are presented. Additional topics include skin effect, reflection of waves and radiation. PREREQUISITE: Vector calculus.

EC 2610 Electromagnetic Engineering (3-2).
A continuation of 2600. Topics include transmission lines, waveguides, cavity resonators, and high frequency components. Applications are presented in the laboratory. PREREQUISITE: 2600.

EC 2650 Accelerated Review of Electromagnetics (4-2).
A comprehensive review of basic electromagnetic theory intended for students who have previously studied the subject matter of 2600 and 2610. PREREQUISITE: Sufficient background in electromagnetic theory. *Graded on Pass/Fail basis only.*

EC 2800 Introduction to Microprocessors (2-1).
A basic understanding of a typical high performance microprocessor and its associated system is developed. A methodology for solving engineering problems through systematic software development and hardware design is introduced. The laboratory sessions provide familiarization with state-of-the-art development tools and emphasize assembly language programming and hardware interfacing using commercially available microprocessor support chips.

EC 2810 Digital Machines (3-2).
An introductory course in the analysis of digital systems and computers. No previous background in electrical engineering or digital techniques is assumed. Topics include: Number systems, logic gates and logic design; arithmetic circuits; flip-flops, counters, registers, and memories; basic digital computer architecture and the internal operation of computers; and elementary machine-language programming. The laboratories are devoted to the study of logic elements, arithmetic circuits, flip-flops, registers, and counters.

EC 2820 Digital Logic Circuits (3-2).
An introductory course in the analysis of digital systems leading up to computers. No previous background in digital concepts or electrical engineering is assumed. Topics include: Boolean algebra, gates, truth tables and Karnaugh maps, integrated circuit families, decoders, multiplexers, PLA's; sequential logic including latches, flip-flops, memories, registers and counters; and sequential machines including state diagrams and synchronous systems.

EC 2830 Digital Design Methodology (3-2).
A design and project oriented course. Basic principles, theories and techniques for practical design of digital systems. Emphasizes an integrated viewpoint combining essential elements of classical switching theory with a thorough understanding of the versatility of modern integrated circuits. Laboratory introduces modern design aids. PREREQUISITE: 2820.

EC 2850 Accelerated Review of Logic Design (4-2).
An advanced review of logic design intended for students who have previously studied the subject matter of 2820 and 2830. PREREQUISITE: Sufficient background in logic circuits and design. *Graded on Pass/Fail basis only.*

Upper Division or Graduate Courses

EC 3310 Linear Optimal Estimation and Control (4-0).
Techniques of optimal control and estimation theory and their application to military systems. Topics include performance measures; dynamic programming, the linear regulator problem; state estimation using observers and Kalman filters; Monte Carlo

simulation; combined estimation and control and case studies. PREREQUISITES: 2300 and 3500 (may be concurrent).

EC 3370 Fundamentals of Automatic Control (3-2).
Formulation of system models including state equations, transfer functions, and system diagrams. Starting with a performance measure, design methods are studied for both transfer function and state equation models. Computer simulation is utilized and physical systems are tested and evaluated. PREREQUISITES: Laplace transform and FORTRAN.

EC 3400 Introduction to Digital Signal Processing (3-0).
Discrete Fourier transforms and the fast Fourier transform (FFT) algorithm, flowgraph and matrix representation of filters, quantization effects, ideal filters and approximations, design of recursive and nonrecursive digital filters. Applications such as the determination of power spectra, filtering of signals and harmonic analysis are considered. PREREQUISITE: 2400.

EC 3410 Introduction to Electro-Optical Engineering (3-1).
An overview of the elements that comprise current electro-optical and infrared (EO/IR) systems. Topics include radiation sources (both laser and thermal), detector devices, modulators, optical elements, and propagation characteristics. Examples of various simple EO/IR systems are discussed. PREREQUISITE: 2210 (may be concurrent).

EC 3420 Fiber Optic Systems Fundamentals (3-1).
An introduction to the components and to the concepts of designing fiber optic communications systems. Includes fiber properties and parameters, fiber fabrication and testing, LED and injection laser sources, pin photodiodes and avalance photodiode detectors, receiver design considerations, connector and splice technologies, and system design incorporating analysis and tradeoffs. Data distribution techniques are also studied. PREREQUISITES: 2220 and 2600.

EC 3440 Image Processing and Recognition (3-0).
Subjects introduced in this course include image representation, enhancement, restorration, transformation, and encoding. Pattern recognition using statistical decision theory will be discussed briefly. Some analysis involving region segmentation and block world understanding will be introduced. Some effort is directed to robotic vision where contemporary techniques used to recognize objects and extract depth information are dealt with briefly. There will be a series of experiments using special peripherals and computers. PREREQUISITE: 2400.

EC 3450 Acoustic Field Theory (4-0).
The objectives of this course are to expose the student to various mathematical techniques (both exact and approximate), special functions (e.g., Bessel functions, Hankel functions, Legendre polynomials, etc.), orthogonality relationships, etc., which will enable him to solve fundamental problems concerning the radiation, scattering and propagation of sound in fluids. Topics to be covered include: general solutions of the three-dimensional Helmholtz wave equation in rectangular, cylindrical, and spherical coordinates with Dirichlet, Neumann, and Robin boundary conditions; radiation and scattering from cylinders and spheres; the method of stationary phase with applications; sound propagation in the ocean — the WKB approximation, ray acoustics, and the parabolic equation approximation; scattering from the ocean surface; and other topics as time permits. PREREQUISITES: EC 2610 or consent of instructor.

EC 3500 Analysis of Random Signals (4-0).
Fundamental concepts necessary for handling non-deterministic signals and noise in communication, control and signal processing systems are developed. Topics include properties of random time functions, statistical averages, autocorrelation and power spectral density, transform relations, stationarity and ergodicity, noise models. PREREQUISITES: 2500 and OS 2102.

EC 3510 Communications Engineering (3-0).
The influence of noise and interference on the design and selection of hardware in practical radio communication transmitters and receivers. Specific topics include link and signal-to-noise ratio calculations, bandwidth trade-offs, carrier and data synchronization methods and hardware parameters. PREREQUISITES: 2220 and 3500.

EC 3570 Communications Systems (4-2).
Analog and digital modulation techniques; complete modulation systems incorporating pulse and pulse code schemes; noise in communication systems; error detection and correction. PREREQUISITE: 2410.

EC 3600 Electromagnetic Radiation, Scattering, and Propagation (3-2).
The principles of electromagnetic radiation as applied to antenna engineering and scattering. The characteristics of various practical antenna types are considered. System parameters such as gain, pattern and cross-section are introduced and array theory is covered. Applications include sidelobe suppression, radar target scattering and satellite communications. PREREQUISITE: 2610.

EC 3610 Microwave Engineering (3-2).
A continuation of 2622, this course covers elements of microwave systems. The course begins with a discussion of circuit media, network characterization with s-parameters and passive circuits such as filters, couplers and impedance transformers. Solid state devices and integrated circuits are then discussed and electron tubes are treated. The course concludes with a study of microwave and millimeter wave propagation. Several laboratory exercises allow the student to pursue selected topics in greater depth in a practical setting. PREREQUISITE: 2610.

EC 3670 Principles of Radar Systems (4-2).
For students in the Avionics and Weapons curricula. Topics include microwave devices, microwave propagation, antenna fundamentals, electronically steerable arrays, pulse radar basics, detection of signals in noise, the radar equation, CW, pulse doppler, moving-target indicators, pulse compression, the ambiguity function, tracking radars, conical scan, track-while-scan, scan with compensation and monopulse. PREREQUISITES: Consent of Instructor, U.S. Citizenship and SECRET clearance.

EC 3800 Microprocessor-Based System Design (3-2).
Advanced microprocessor system concepts are studied. Multimaster and multiprocessor systems issues. Memory management issues. Coprocessors and other advanced VLSI peripheral devices. HLL for solving engineering applications and linkage to OS and assembly language programs. The laboratory sessions will emphasize a design project involving advanced microprocessor-system concepts. PREREQUISITES: 2800 and 2830.

EC 3820 Computer Systems (3-1).
The course presents a unified approach design of computer systems stressing the interacting processes implemented in hardware, software and firmware. General features of operating systems are studied as well as specific features of an existing system. The elements of multiprogramming systems are introduced. PREREQUISITE: 2800.

EC 3830 Digital Computer Design (3-1).
A study of the architecture of and the design process for digital computer systems. Topics covered will include instruction set architectures, advanced computer arithmetic, hierarchical design techniques, design of systems using standard and custom VLSI devices, Modern computer aided-design tools are emphasized. Laboratory project is the design of a digital computer. PREREQUISITES: 2800 and 2830.

EC 3850 Computer Communication Methods (3-0).
The course objective is to develop an understanding of computer communications network design. Coverage includes the essential topics of network topology, connectivity, queueing delay, message throughput and cost analysis. The International Standard Office (ISO) model is divided into physical link, data link, network, transport, session and application layers. The protocol of these layers, data framing, error control, flow control, packet assembly/disassembly, routing, congestion, virtual circuit connection are discussed. New lower networking technologies such as Ethernet, ring, satellite link, X.25 public packet switching are introduced. PREREQUISITE: 2500.

EC 3870 VLSI Systems Design (3-2).
An introduction to the technology and design of very-large-scale-integrated systems. Emphasizing NMOS devices and circuits, a structured approached to system design is developed. The approach is based upon the use of repetitive cell structures and highly regular topologies. A complete VLSI system example is presented in detail. Project work is oriented to system and layout planning of a small system. PREREQUISITE: 2830.

EC 3910 Topics in Electrical Engineering (3-0 or 4-0).
This course examines topics of current interest in the field of electrical engineering. PREREQUISITE: Consent of Instructor.

Graduate Courses

EC 4100 Advanced Network Theory (4-0).
Topology, circuit formulation, nonlinear modeling, and computer solutions. Circuit sensitivity models. Concepts and test for passivity, activity, causuality, and stability. Driving point synthesis. Transfer function properties and synthesis to meet design criteria. Design with inductorless filters, switched-capacitor filters, operational amplifiers and integrated circuit components. PREREQUISITES: 2210, 2410 and 2420.

EC 4300 Advanced Topics in Modern Control Theory (3-0).
Advanced topics and current developments in control theory and applications including such subjects as: the calculus of variations and Pontryagin's minimum principle applied to optimal control problems; numerical solution of two-point boundary-value problems; nonlinear estimation techniques; robust design techniques; large-scale systems; system identification; case studies of fire control and ship control systems. PREREQUISITES: Consent of Instructor.

EC 4310 Digital Control Systems (3-0).
Discrete systems are described and analyzed using time-domain and z-transform methods. Analytical design techniques are studied, as well as the engineering characteristics of computer control systems. PREREQUISITES: 2400 and 3310.

EC 4320 Design of Linear Control Systems (4-0).
Advanced concepts in the design of linear systems. Frequency response and root locus methods are applied to the design of stabilization and improvement of performance, using both graphical and analytical (algebraic) methods. For more complex systems, the Mitrovic-Siljak relationships are developed, leading to coefficient plane, parameter plane and parameter space and singular line methods. PREREQUISITE: 3310.

EC 4330 Navigation, Missile, and Avionics Systems (4-0).
The principles of operation of navigation, missile and avionics systems are presented. Topics are selected from the following areas to address the specific interests of the class: IR, EO, radar, laser, and acoustic sensors; inertial platforms; gyros and accelerometers; Loran, Omega, GPS, guidance, fir control, and tracking systems. PREREQUISITES: 3310, U.S. Citizenship and SECRET clearance.

EC 4340 Navigation, Missile and Avionics Systems (4-0).
This course covers essentially the same material as 4330, but with deletion of detailed analysis of specific systems. This course is intended for officers who do not have U.S. Citizenship. PREREQUISITE: 3310.

EC 4350 Nonlinear Systems (3-2).
Analysis and design of nonlinear systems with phase plane and describing function methods. Accuracy, limit cycles, jump resonances, relay servos and discontinuous systems are considered. PREREQUISITE: 2300.

EC 4360 Ship Control Systems (4-0).
Theory of motion of ships. Basic ship control systems: steering control, roll stabilization, boiler control loops, speed and propulsion controls. Sea states and their effects. Performance objectives and performance specifications; models and simulation studies. PREREQUISITE: 2300.

EC 4370 Mathematical Models and Simulation for Control Systems (4-0).
Modeling concepts and techniques for linear and nonlinear systems. Philosophy of model studies. Verification of the model and its parameters. Design studies using computer models. PREREQUISITE: 2300.

EC 4410 Electro-Optic Systems Engineering (3-0).
Advanced topics and applications of electro-optics. Military applications of infrared technology. Signal-to-noise analysis of laser detector performance. Descriptions of high energy lasers, fiber optics or other topics. Student reports on EO/IR topics of current interest. PREREQUISITE: 3410.

EC4430 Principles of Digital Filters (4-0).
Design and implementation of digital signal processing algorithms. Included are a review of FIR and IIR linear filter design techniques with emphasis on structures, implementations, and quantization effects (finite register lengths, correlated and uncorrelated noise). Least square estimation filters including discrete Weiner filtering (stochastic deconvolution), linear prediction, autoregressive moving average processing, Levinson's algorithm and lattice structures, and self adaptive filters. PREREQUISITE: 3400.

EC 4440 Multidimensional Digital Signal Processing (3-0).
Fundamentals of digital signal processing for signals that are a function of two or more independent variables. Analysis in both the time/space and frequency domains. Areas where the theory of one-dimensional signal processing does not extend in any straight forward way to two or more dimensions are highlighted. Topics include convolution, difference equations, recursively computable systems, sampling, regions of support, multidimensional periodicity, Fourier analysis including discrete Fourier transforms, z-transforms, stability, multidimensional causality, and an introduction to filter design. PREREQUISITE: 3400.

EC 4450 Sonar Systems Engineering (4-1).
Mathematical development and discussion of fundamental principles that pertain to the design and operation of passive and active sonar systems. Topics from complex aperture theory, array theory, and signal processing are covered. PREREQUISITES: EC 3450 or PH 3452 or PH 3472 and EC 3500 or EC 4720.

EC 4460 Principles of Systems Engineering (4-0).
An introduction to the concepts, principles, methodology, and techniques of the design of large scale systems. Lecture topics include the systems approach; the system life cycle and system design process; determining system requirements from operational requirements; system effectiveness, reliability, maintainability, safety, and logistic support considerations; test and evaluation; and cost as a design parameter. Applications to Navy electronics systems are used to illustrate the subjects covered. A detailed case study analysis of a specific Navy system is performed by the students. PREREQUISITE: Consent of Instructor.

EC 4470 Underwater Acoustic Systems Engineering (4-1).
Mathematical development and discussion of fundamental principles that pertain to the design and operation of passive and active sonar systems. Topics from complex aperture theory, array theory, and signal processing are covered. PREREQUISITE: 3500.

EC 4480 Signals Intelligence (SIGINT) Systems Engineering (2-2).
Airborne, shipboard, and ground based interept and direction finding system techniques used against simple and sophisticated electromagnetic radiation systems. Among the topics covered are current state of the art for wideband and directional antennas, wideband RF preamplifiers, scanning and chirping receivers, displays, recorders, pattern recognizers, and signal analysis devices. The laboratory periods are largely devoted to the specification and block diagram of systems to handle specified SIGINT tasks. PREREQUISITES: Consent of Instructor; U.S. Citizenship and SECRET clearance.

EC 4550 Digital Communications (4-0).
This course discusses some of the advantages and limitations of digital communications systems, to include: common modulation formats, matched-filter receivers, probability of error calculations, non-coherent receivers, carrier synchronization, frame and bit synchronization, telephone line modems, inter-symbol interference and adaptive equalizers, wide-band modems, exchange of band-width and signal-to-noise ratio, diversity combining, maximum-likelihood and maximum aposterior probability receivers, and channel capacity and finite-rate communication with arbitrarily few errors. PREREQUISITE: 3510.

EC 4560 Communications ECCM (3-2).
Methods of reducing the effects of jamming on radio communications systems are considered. Matched filter and correlator theory and application to spread spectrum techniques of digital data transmission are treated. Synchronization problems and techniques are presented. Codes for error correction are briefly considered. Frequency hopping, time hopping, and hybrid systems are studied in addition to direct sequence spreading. Use of steerable null antennas is described. PREREQUISITE: 3510.

EC 4570 Decision and Estimation Theory (4-0).
Principles of optimal signal processing techniques for detecting signals in noise are considered. Topics include Maximum-Likelihood, Bayes Risk, Neyman Pearson and Min-Max criteria and calculations of their associated error probabilities (ROC curves) for signals in Gaussian noise. Principles of Maximum-Likelihood, Bayes Cost, MMSE and Maximum-Aposterior estimators are introduced. Asymptotic properties of estimators and the Cramer-Rao bound are developed. The estimator-correlator structure is derived for detection of signals with unknown parameters. This structure is illustrated by development of the radar (sonar) ambiguity function and matched filter processing systems. State estimation and the Kalman filter are derived and related to MMSE estimators. Emphasis is on dual development of continuous time and discrete time approaches, the latter being most suitable for digital signal processing implementations. PREREQUISITE: 3500.

EC 4580 Information Theory (3-0).
Concepts of information measure for discrete and continuous signals. Fundamental theorems relating to coding and channel capacity. Effects of noise on information transmission. Coding methods for error control in digital communication systems. Selected applications of the theory to systems. PREREQUISITE: 3500.

EC 4590 Communication Satellite Systems Engineering (3-0).
Communication satellite systems including the satellite and user terminals. Subjects include orbits, power sources, antennas, stabilization, link calculations, multiple access techniques, modulation and demodulation schemes, phase-locked loops, coding, transponder intermodulation and hardlimiting, receiver design, spread spectrum in SATCOM for multiple access, anti-jam and covert communications. PREREQUISITE: 3510. (May be concurrent).

EC 4600 Advanced Electromagnetic Theory (3-0).
An introduction is provided to advanced mathematical and numerical techniques of importance in the solution of electromagnetic problems. Applications of interest in the areas of antennas and microwave theory are covered. These include radiation and scattering from wires and surfaces and wave propagation on structures used in microwave integrated circuitry. PREREQUISITE: 3600 or 3610. .

EC 4610 Radar Systems (3-2).
The radar range equation is developed in a form including signal integration, the effects of target cross-section, fluctuations, and propagation losses. Modern techniques discussed include pulse compression frequency-modulated radar, MTI, pulse doppler systems, monopulse tracking systems, multiple-unit steerable array radars, and synthetic aperture systems. Laboratory sessions deal with basic pulse radar systems from which the advanced techniques have developed, with pulse compression, and with the measurements of radar cross section of targets. PREREQUISITES: 3500 and 3610 (may be concurrent), or equivalent; U.S. Citizenship and SECRET clearance.

EC 4620 Radar Systems (3-2).
This course covers essentially the same material as 4610, but with deletions of detailed analysis of specific items. PREREQUISITES: 3500 and 3610 (may be concurrent), or equivalent. *This course is intended for students who do not have U.S. Citizenship.*

EC 4660 High Frequency Techniques (4-0).
The high frequency path from transmitter multicoupler to receiver multicouplers. Topics include HF propagation, propagation prediction, sounders, nuclear effects, ionospheric noise and interference, dynamic range problems, antenna and site effects, and target location techniques. PREREQUISITES: 3600, or consent of Instructor; U.S. Citizenship and SECRET clearance.

EC 4670 Electronic Warfare (4-1).
This course is intended for students who are not in the Electronics or Communications Engineering curricula. Three lecture hours are shared with 4680. In addition to the topics listed under 4680, background material on communication theory and digital signal processing is presented. PREREQUISITES: 3670, U.S. Citizenship and SECRET clearance.

EC 4680 Electronic Warfare Techniques and Systems (3-3).
Active and passive countermeasure techniques are considered, including signal representation, signal analysis, and signal interception. Important parameters of radar and communications systems are defined. Denial and deceptive jamming techniques are considered along with countermeasure and counter-countermeasure techniques.

Signal intercept systems are treated. Acoustic, radio-frequency, infrared, and optical countermeasures are discussed. PREREQUISITES: 4610, U.S. citizenship and SECRET clearance.

EC 4690 Principles of Electronic Warfare *(unclassified)* **(3-2).**
For students who do not have U.S. citizenship. The objectives are to define EW signals and system parameters, and establish interrelationships of these parameters for active and passive EW systems. Topics studied are signal waveforms and spectra, receivers, signal processing and display, jamming techniques, direction finding, deception and confusion techniques. Laboratory exercises apply the basic principles of jamming and CCM to radar systems. PREREQUISITE: 4620.

EC 4820 Computer Architectures (3-1).
A study of advances in computer architecture. Computer descriptive languages. Memory system issues. Mini-computers and bit-slice microcomputers. High performance computers: pipeline supercomputers, array processors, multiprocessors. Data flow architectures. Fault tolerant and military architectures. PREREQUISITE: 3800 and 3820 or 3830.

EC 4900 Special Topics in Electrical Engineering (2-0 to 5-0).
Supervised study in selected areas of electrical engineering to meet the needs of the individual student. A written report is required at the end of the quarter. PREREQUISITE: Consent of the Department Chairman. *Graded on Pass/Fail basis only.*

EC 4910 Advanced Topics in Electrical Engineering (3-0 or 4-0).
This course examines advanced topics of current interest in the field of electrical engineering. PREREQUISITE: Consent of Instructor.

COURSES FOR INTERDISCIPLINARY CURRICULA

EC 0170 Electrical Principles Refresher (5-2).
A six-week course designed to introduce and/or refresh incoming officers in selected basic concepts of electrical engineering. The laboratory periods are used to learn to use modern electronic test equipment.

Upper Division Courses

EC 2710 Introduction to Signals and Systems (3-2).
The progression from circuits, to filters, to systems, emphasizing input/ouput relationships in the time and frequency domain, is developed. Students are introduced to the most used mathematical representations of analog and discrete signals used in communications and signal analysis. Communications control and signal processing concepts of electrical engineering are overviewed. Examples of voice and data communications links, signal analysis and target identification and tracking will be given. PREREQUISITE: MA 2050.

EC 2720 Introduction to Electronic Systems (4-2).
A first course in electronic systems for the ASW and EW systems curricula. Emphasis is on the functional aspects of basic circuits and signals. Topics include electrical quantities, resistive circuits, inductance and capacitance, operational amplifiers, time and frequency response, rectifiers and logic elements. PREREQUISITE: Calculus.

EC 2730 Control Systems (2-1).
This course develops the basic tools of the control systems engineer. The applications to electronic warfare are emphasized in the examples and laboratory experiments. The dynamics for a radar control system, a missile seeker head tracking system and missiles are investigated. Basic topics are introduced such as signal flow graphs and system step and frequency response characteristics, and digital systems theory as used in radar tracking and command guided and semiactive homing missiles. PREREQUISITES: Differential equations, Laplace transform and FORTRAN.

EC 2740 Communications Systems (3-2).
Digital and analog communications systems with identification of subsystems; sampling, code conversion oscillators, modulation and demodulation, special purpose circuits, elementary communication theory, Fourier analysis, ideal filters, and multiplexing techniques. PREREQUISITE: 2710 or 2720.

EC 2750 Signal Transmission Systems (4-1).
The elements of electrical energy transmission as applied to communications. The principles of electromagnetic waves, guided waves on transmission lines, and waveguides are studied. The radiated field in space, antennas, and propagation are covered, and a representative system, such as a satellite communications system is studied. PREREQUISITE: 2740.

EC 2760 Electromagnetic Theory (4-1).
The experimental laws of electromagnetic theory and the development of Maxwell's equations are presented. Maxwell's equations are then utilized in the study of plane waves, transmission lines, wave guides, cavity resonators, and elementary radiation. Laboratory experiments dealing with high frequency components and measurements reinforce and extend the concepts presented in the lectures. PREREQUISITES: 2720 and MA 2181.

EC 2790 Communications Systems (4-0).
This course supports the Intelligence curriculum by providing an overview of the principles, concepts, and trade-offs underlying communications systems. Topics include: signals and their representation as functions of time and frequency, effects of bandwidth limitations upon signals, analog and ditital modems, signal-to-noise considerations in communications systems, reliable communications path concepts, major communications system design trade-offs, and examples of modern communications systems.

Upper Division or Graduate Courses

EC 3720 Introduction to Signals and Noise (4-1).
A course in the analysis of signals and noise for the ASW, EW and C3 curricula. Topics include Fourier analysis of periodic and pulse signals, linear filter response, correlation and spectral density of random signals and sampling. PREREQUISITES: 2710 or 2720 and a first course in probability.

EC 3750 Communication System Analysis (3-2).
The final course in the Telecommunications Systems sequence. The objective is to study the overall communication system with concentration in the system aspects rather than in devices. Topics include: signal waveforms and spectra, modulation techniques, power budget, diversity systems, propagation problems, codes and error control, network components, protocol, and system planning considerations including possible trade-offs. PREREQUISITE: 2750.

EC 3760 Electromagnetic Radiation, Scattering, and Propagation (4-2).
The fundamentals of antennas used in the VLF through the microwave portion of the electromagnetic spectrum are presented. Scattering and propagation in this part of the spectrum are also discussed, as are those elements of electromagnetic compatibility which relate to radiation. Laboratory exercises relating to pattern and impedance measurement, and use of computer programs further enhance the student's understanding of the lecture concepts. PREREQUISITE: 2760.

Graduate Courses

EC 4720 Signal Processing Systems (4-1).
A study of digital, analog, and hybrid signal processing systems for communications, echo ranging, and electronic surveillance. Examples from current and proposed military systems will be analyzed. The course is designed for the ASW and EW curricula. PREREQUISITE: 3720.

EC 4730 Electro-Optic Systems and Countermeasures (3-1).
A study of military applications of electro-optic systems, IR and EO missile seekers, laser designators, optical surveillance, high energy laser systems, laser communications, and laser radar. Emphasis is on system applications, countermeasures and counter countermeasures. Students report on electro-optic systems. PREREQUISITES: 4410 or PH 3271; U.S. Citizenship and SECRET clearance.

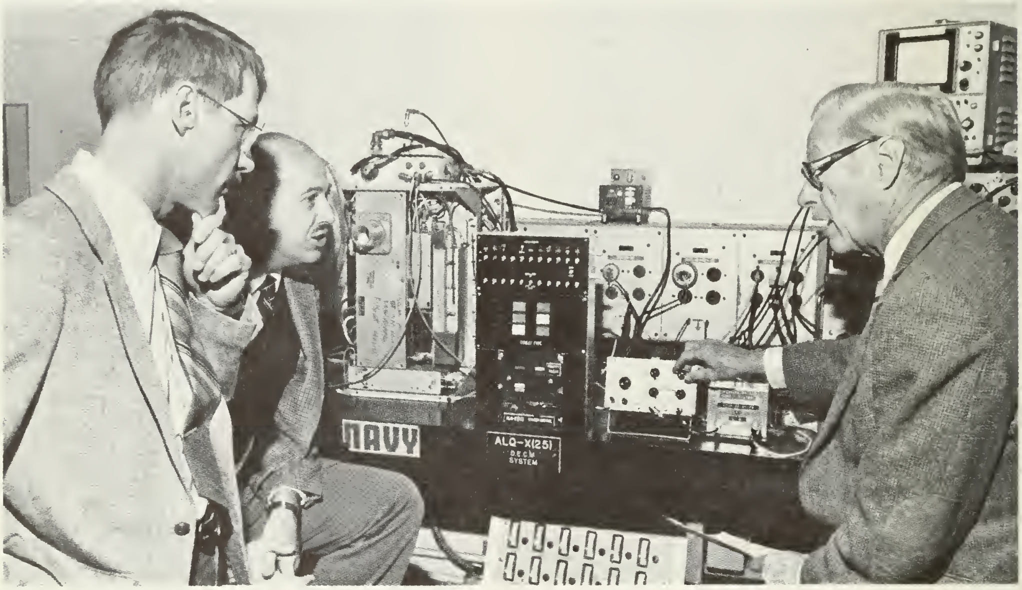
EC 4740 Telecommunications Networks (4-0).
Transmission of digital data, to include modulation/demodulation and error detection/correction techniques. Multiple access via line switching, packet switching, and ALOHA techniques. Analysis of queuing, blocking, delay and thruput. Protocol requirements, routing, and flow control in large-scale interconnected systems. Subnetwork compartmentalization, digitized voice and network reliability. Examples of existing and proposed systems. PREREQUISITE: 3720.

EC 4760 Microwave Devices and Radar (4-2).
Those microwave devices most important in radar and in electronic warfare systems are studied, including magnetrons, traveling-wave tubes, and solid-state diodes. The radar range equation is developed. In addition to basic pulse radar, modern techniques are discussed including doppler systems, tracking radar, pulse compression, and electronically steerable array radars. Electromagnetic compatibility problems involving radar systems are considered. Laboratory sessions deal with basic pulse radar systems from which the advanced techniques have developed, with performance measurement methods, automatic tracking systems, pulse compression, and the measurement of radar cross section of targets. PREREQUISITES: 4720, 3760 (may be taken concurrently) or consent of Instructor, U.S. Citizenship and SECRET clearance.

EC 4780 Electronic Warfare Systems (3-2).
This course covers electronic warfare in that portion of the electromagnetic spectrum through the millimeter wavelength region. The infrared through electro-optic region is covered in a companion course, EC 4423. Electronic denial and deceptive countermeasures against fuses, communications, and various radar detection and tracking systems are discussed. Equations for required jammer gain and power output are developed. The characteristics of passive countermeasures are discussed. Other topics include anti-radiation missiles, counter countermeasure circuits, target masking and modification, signal intercept, signal sorting, signal identification, and direction finding. Techniques are discussed in relation to U.S., allied, and communist bloc systems. Laboratory work reinforces the classroom discussions. PREREQUISITES: 4760, U.S. Citizenship and SECRET clearance.

EC 4790 Electronic Warfare and C3 Systems (4-0).
The vulnerability of command, control, and communication systems to electronic warfare and signal analysis is examined. A background in electromagnetic propagation in layered media is developed and used to investigate phenomena such as ionospheric propagation, ducting, and electromagnetic attenuation in seawater. The dependence of propagation phenomena on frequency is illustrated with examples taken from ELF through millimeter waves. Elementary antennas are treated, with emphasis on their farfield patterns. The directional properties of array antennas are developed and used to study electronically-steered multiple-beam antennas such as those used in Aegis. The capabilities and limitations of direction-finding intercept antennas are discussed. SIGINT system operations are explored from the points of view of both offense and defense. Specifically for students in the C3 curriculum. PREREQUISITE: 3720.

ELECTRONIC WARFARE GROUP



Professor and students discussing EW lab proceedure

The Electronic Warfare Academic Group has administrative responsibility for the academic content of the Electronic Warfare Systems Engineering curriculum. Teaching in this multi-disciplinary program is carried out by faculty members attached to the following academic departments: Computer Science, Electrical Engineering, Mathematics, Meteorology, National Security Affairs, Operations Research, and Physics and Chemistry. Members of the Academic Group are:

John Miller Bouldry, Associate Professor of Electrical Engineering; Chairman (1946)*; B.S., Northeastern Univ., 1941; M.S., Brown Univ., 1956.

Alfred William Madison Cooper, Professor of Physics (1957); B.A., Univ. of Dublin, 1955; M.A., 1959; Ph.D., The Queen's Univ. of Belfast, 1961.

Kenneth LaVern Davidson, Professor of Meteorology (1970); B.S., Univ. of Minnesota, 1962; M.S., Univ. of Michigan, 1966; Ph.D., 1970.

Jeffrey Bruce Knorr, Professor of Electrical Engineering (1970); B.S., Pennsylvania State Univ., 1963; M.S., 1964; Ph.D., Cornell Univ., 1970.

Frank Marchman Perry, Lieutenant Colonel, U.S. Army; Instructor in Operations Research (1983); B.S., U.S. Military Academy, 1967; M.S., Naval Postgraduate School, 1975.

Edward Brandt Rockower, Adjunct Professor of Operations Research (1984); B.S., Univ. of California at Los Angeles, 1964; M.A., Brandeis University; 1967; Ph.D., 1975.

Arthur Loring Schoenstadt, Professor of Mathematics (1970); B.S., Rensselaer Polytechnic Institute, 1964; M.A., 1965; Ph.D., 1968.

Andrew Peter Sosnicky, Commander, U.S. Navy; Curricular Officer; B.S., U.S. Naval Academy, 1966; M.S. in Telecommunications Systems Management, Naval Postgraduate School, 1976; M.S. in Administration, George Washington Univ., 1978.

Lonnie Allen Wilson, Associate Professor of Electrical Engineering (1979); B.S.E.E., Walla Walla College; M.S., Univ. of California at Los Angeles, 1969; Ph.D., 1973.

**The year of joining the Postgraduate School Facility is indicated in parentheses.*

MASTER OF SCIENCE IN SYSTEMS ENGINEERING

1. The degree of Master of Science in Systems Engineering will be awarded at the completion of a multidisciplinary program, Curriculum 595, satisfying the following degree requirements:
    a. The Master of Science in Systems Engineering requires a minimum of 45 quarter hours of graduate level work of which at least 15 hours must represent courses at the 4000 level. Graduate courses in at least four different academic disciplines must be included, and in two disciplines, a course at the 4000 level must be included.
    b. An approved sequence of at least three courses constituting advanced specialization in one area must be included.
    c. In addition to the 45 hours of course credit, an acceptable thesis must be completed.

DEPARTMENTAL COURSE OFFERINGS

EW 0002 Seminar (0-1).
Special lectures and discussion of matters related to the EW program. PREREQUISITE: SECRET clearance.

EW 0810 Thesis Research/Group Project (0-0).
Students in the Systems Engineering curricula will enroll in this course which consists of an individual thesis or a group project involving several students and faculty.

Upper Division or Graduate Courses

EW 3020 Electronic Warfare Computer Applications (3-2).
Application of digital and analog techniques to the recording, processing, display, and interpretation of electronic warfare signals and data. The computer is applied to the solution of electronic warfare problems such as signal identification. PREREQUISITES: EE 2810, CS 3510, or CS 3230; EE 4484.

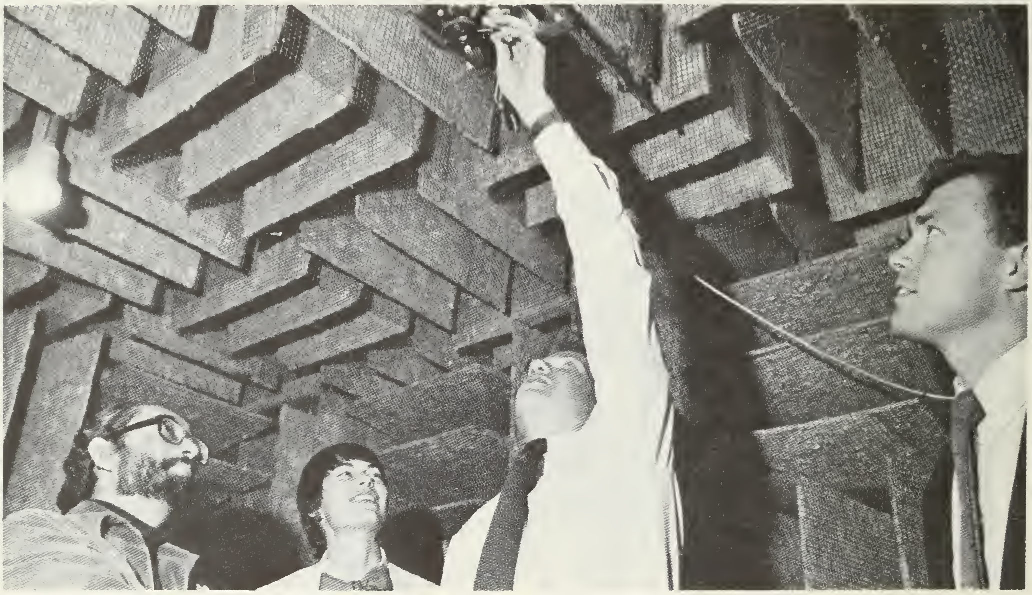
EW 3486 Signals Intelligence (2-0).
This course focuses on U.S. signals intelligence capabilities for countering current threats and the processes for designing or upgrading U.S. capabilities. It is designed to enhance the student's knowledge and understanding of current and planned U.S. SIGINT systems and capabilities and the design, development and employment of SIGINT and ESM systems. PREREQUISITE: Registration in EW curriculum 595 or consent of Instructor. U.S. Citizenship and SI clearance.

Graduate Courses

EW 4453 Underwater Sound, Systems, and Countermeasures (3-2).
A study of the principles of underwater sound propagation, and the design and operational characteristics of underwater sound systems. Emphasis is placed on various measures used to interfere with and to deceive active and passive Sonar systems, and the techniques used to counter this interference. Topics studied include: sensor arrays, acoustic propagation, noise, acoustic quieting, signal processing, and examples of active and passive underwater acoustic systems, including acoustic countermeasures. PREREQUISITES: PH 2123, U.S. Citizenship and SECRET clearance.

EW 4900 Special Topics in Electronic Warfare (2-0 to 5-0).
Supervised study in selected areas of electronic warfare to meet the needs of individual students. A written report is required at the end of the quarter. PREREQUISITE: Consent of Group Chairman. *Graded on a Pass/Fail basis only.*

ENGINEERING ACOUSTICS PROGRAMS



Getting the "Bugs" out of the Anechoic Chamber

The academic character of programs in Engineering Acoustics is interdisciplinary, with courses drawn principally from the fields of electrical engineering, physics, and computer science. Although broadly based, the emphasis of the programs is on those aspects of acoustics, signal processing, and computer science related to detecting, tracking, and classification of underwater targets. These programs are designed for students in the Underwater Acoustic Systems Curriculum.

The academic aspects of the programs are the responsibility of an academic committee composed of representatives from the Departments of Electrical Engineering, Physics, and Computer Science; currently chaired by Associate Professor James V. Sanders of the Department of Physics.

DEGREE REQUIREMENTS MASTER OF SCIENCE IN ENGINEERING ACOUSTICS

1. A student pursuing a program leading to a Master of Science in Engineering Acoustics must have completed work which would qualify him for a Bachelor of Science degree in engineering or physical science.

2. The Master of Science in Engineering Acoustics requires a minimum of 36 graduate credit quarter hours of course work; at least 20 graduate quarter hours must be taken in acoustics and its applications. One 4000 level course from each of three of the following areas must be included: wave propagation, vibration and noise control, transducer theory, sonar systems, and signal processing.

3. An acceptable thesis must be completed.

4. Approval of each program by the Engineering Acoustics Academic Committee must be given before the midpoint of the degree program.

DOCTORAL PROGRAMS IN ENGINEERING ACOUSTICS

The Departments of Electrical Engineering and Physics jointly sponsor an interdisciplinary program in Engineering Acoustics leading to either the degree Doctor of Philosophy or Doctor of Engineering. Areas of special strength in the departments are physical acoustics, ocean acoustics, and acoustic signal processing. A noteworthy feature of this program is that a portion of the student's research may be conducted away from the Naval Postgraduate School at a cooperating laboratory or other federal government installation. The degree requirements and examinations are as outlined under the general school requirements for the Doctor's degree. In addition to the school requirements, the departments require a preliminary examination to show evidence of acceptability as a doctoral student.

DEPARTMENT OF MATHEMATICS

Math professors discussing the use of microcomputers in the classroom

Gordon Eric Latta, Professor of Mathematics; Chairman (1979)*; B.S., Univ. of British Columbia, 1946; Ph.D., California Institute of Technology, 1951.

Donald Alfred Danielson, Associate Professor of Mathematics (1985); B.S., Massachusetts Institute of Technology, 1964; Ph.D., Harvard Univ., 1968.

Richard Homer Franke, Professor of Mathematics (1970); B.S., Fort Hays Kansas State College, 1959; M.S., Univ. of Utah, 1961; Ph.D., 1970.

Harold Marvin Fredricksen, Associate Professor of Mathematics (1980); B.A., Los Angeles State College, 1962; M.S., Univ. of Wisconsin, 1964; Ph.D., Univ. of Southern California, 1968.

Toke Jayachandran, Professor of Mathematics (1967); B.S., V.R. College, Nellore, India, 1951; M.S., Univ. of Wyoming, 1962; Ph.D., Case Institute of Technology, 1967.

Ladis Daniel Kovach, Professor of Mathematics (1967); B.S., Case Institute of Technology, 1936; M.S., 1948; M.A., Western Reserve Univ., 1940; Ph.D., Purdue Univ., 1951.

Kenneth Robert Lucas, Associate Professor of Mathematics (1958); B.S., Washburn Univ., 1949; Ph.D., Univ. of Kansas, 1957.

Raul Hernan Mendez, Assistant Professor of Mathematics (1981); B.S., Purdue Univ., 1969; M.S., Univ. of California at Berkeley, 1971; Ph.D., 1977.

George William Morris, Professor of Mathematics (1968); B.A., Southwestern Oklahoma State Univ., 1942; M.A., Univ. of Oklahoma, 1947; Ph.D., Univ. of California at Los Angeles, 1957.

Guillermo Owen, Professor of Mathematics (1983); B.S., Fordham Univ., Ph.D., Princeton Univ., 1962.

Ira Bert Russak, Associate Professor of Mathematics (1972); M.E., Stevens Institute of Technology, 1957; M.A., Univ. of California at Los Angeles, 1962; Ph.D., 1967.

Arthur Loring Schoenstadt, Associate Professor of Mathematics (1970); B.S., Rensselaer Polytechnic Institute, 1964; M.A., 1965; Ph.D., 1968.

Donald Herbert Trahan, Associate Professor of Mathematics (1966); B.S., Univ. of Vermont, 1952; M.A., Univ. of Nebraska, 1954; Ph.D., Univ. of Pittsburgh, 1961.

James Lewis Wayman, Adjunct Professor of Mathematics (1981); B.S., Univ. of California at Santa Barbara, 1972; M.S., 1975; Ph.D., 1980.

Maurice Dean Weir, Associate Professor of Mathematics (1969); B.A., Whitman College, 1961; M.S., Carnegie-Mellon Univ., 1963; D.A., 1970.

Carroll Orville Wilde, Professor of Mathematics (1968); B.S., Illinois State Univ., 1958; Ph.D., Univ. of Illinois, 1964.

Larry James Williamson, Adjunct Professor of Mathematics (1982); B.A., San Francisco State University, 1969; M.A., 1971; Ph.D., Univ. of California, Berkeley, 1973.

Walter Max Woods, Professor of Mathematics (1962); B.S., Kansas State Teachers College, 1951; M.S., Univ. of Oregon, 1957; Ph.D., Stanford Univ., 1961.

Emeritus Faculty

Willard Evan Bleick, Professor Emeritus (1946); M.E., Stevens Institute of Technology, 1929; Ph.D., Johns Hopkins Univ., 1933.

Frank David Faulkner, Distinguished Professor Emeritus (1950); B.S., Emporia State Univ., 1940; M.S., Kansas State Univ., 1942; Ph.D., Univ. of Michigan, 1969.

Robert Eugene Gaskell, Professor Emeritus (1966); A.B., Albion College, 1933; M.S., Univ. of Michigan, 1934; Ph.D., 1940.

Joseph Giarratana, Professor Emeritus (1946); B.S., Univ. of Montana, 1928; Ph.D., New York Univ., 1936.

Carl Adolf Hering, Professor Emeritus (1946); B.S., Oregon State College, 1941; M.S., Cornell Univ., 1944.

Brooks Javins Lockhart, Professor Emeritus (1948); B.A., Marshall Univ., 1937; M.S., West Virginia Univ., 1940; Ph.D., Univ. of Illinois, 1943.

John Philip Pierce, Professor Emeritus (1948); B.S.E.E., Worcester Polytechnic Institute, 1931; M.S.E.E., Polytechnic Institute of Brooklyn, 1937.

Robert Fross Rinehart, Dean Emeritus (1965); B.A., Wittenberg College, 1930; M.A., Ohio State Univ., 1932; Ph.D., 1934; D.Sc., Wittenberg Univ., 1960.

Elmo Joseph Stewart, Professor Emeritus (1955); B.S., Univ. of Utah, 1937; M.S., 1939; Ph.D., Rice Univ., 1953.

James Woodrow Wilson, Professor Emeritus (1949); B.A., Stephen F. Austin State, 1935; B.S., in Ch.E., Univ. of Texas, 1939; M.S., in Ch.E., Texas A&M College, 1941.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN MATHEMATICS

The Department of Mathematics offers the Master of Science degree to qualified students. An interested student should consult the Chairman of the Mathematics Department for an evaluation of his previous academic record to determine his potential for successfully completing a degree program.

If the student's previous record is found to be adequate, a mathematics program is designed which satisfies the Departmental requirements and fits the interest, preparation and aptitude of the student. The program, and subsequent changes in the program, must be approved by the Departmental Chairman.

A student whose background is deemed insufficient for entrance may take courses to reach entrance level, however such courses cannot be counted toward degree requirements.

MASTER OF SCIENCE IN APPLIED MATHEMATICS

1. In order to enter a program leading to the degree Master of Science in Applied Mathematics, a student must have a background which would qualify him for a Bachelor of Science degree with major in mathematics or, with a strong mathematical orientation, in a physical science or engineering.

2. A program that leads to the degree Master of Science in Applied Mathematics for a student who has met the entrance criteria must contain a minimum of 45 quarter hours of graduate level courses with a minimum QPR of 3.0, subject to the following conditions:

a. The program must be approved by the Chairman of the Department of Mathematics.
b. The program must include at least fifteen hours at the 4000 level, with at least twelve hours in 4000 level mathematics courses.
c. The program must contain at least nine hours in an approved sequence of applications courses from outside the Mathematics Department, and at least nine hours in an approved sequence of courses from within the Mathematics Department.
d. An acceptable thesis is normally required and is credited as the equivalent of nine hours of 3000 level mathematics courses. (A student may petition the Chairman of the Mathematics Department to substitute nine hours of courses for the thesis.)
e. Courses in the following areas are specifically required in any program; some of these courses may be used to satisfy part (or all) of the mathematics sequence requirement in item (2.c.) above:
(1) Real/complex analysis (a two-course sequence), or applied algebra (a two-course sequence)
(2) Ordinary and/or Partial Differential Equations and Integral Transforms
(3) Numerical Analysis
(4) Probability and Statistics

MASTER OF SCIENCE DEGREE WITH MAJOR IN MATHEMATICS

1. In order to pursue a program leading to the Master of Science degree with a major in mathematics, a student must have a background which would qualify him for a Bachelor of Science degree with major in mathematics.

2. A curriculum which satisfies the Master of Science degree requirements consists of a minimum of 45 quarter hours of approved courses in mathematics and related subjects. An acceptable thesis may be counted as equivalent to nine quarter hours. A student must have a QPR of 3.0 or greater in any major program.

3. At the discretion of the Chairman of the Department of Mathematics, a student pursuing a program leading to the Master of Science degree with major in mathematics may (or may not) be required to write a thesis in mathematics.

4. The following topics are specifically included in any major program.
   a. 6 hours of Algebra
   b. 6 hours of Analysis

5. The main areas of thesis topics are
   a. Optimization
   b. Differential Equations
   c. Fourier Analysis
   d. Functional Analysis
   e. Numerical Methods
   f. Optimal Control
   g. Calculus of Variations
   h. Tensor Analysis and Applications

DEPARTMENTAL COURSE OFFERINGS

MA 0110 Refresher for the TI-59 Programmable Calculator (2-0).
Numerical calculations and basic programming on the TI-59 programmable calculator. Numerical calculations include use of the power and root keys, log and exponential keys, trigonometric and inverse trigonometric keys, and scientific and floating point notation. Basic programming includes use of the label and editing keys, read and write keys, printing, conditional and unconditional branching, loops, subroutines, use of the solid state library modules, and indirect addressing. (A TI-59 programmable calculator is required; a PC 100A printer is desirable, but not required.)

MA 0112 Refresher Mathematics (5-5).
Calculus Review.

MA 0125 Logic and Set Theory (5-0).
An introduction to the elements of set theory and mathematical reasoning. Sets, Venn Diagrams, truth tables, quantifiers, logical reasoning. Functions, relations, partitions and equivalence relations. 1-1 correspondence. (Paradoxes of set theory, axiom of choice.) PREREQUISITE: None.

MA 0810 Thesis Research (0-0).
Every student conducting thesis research will enroll in this course.

MA 1070, 1080, 1081 and 1082 constitute the Technical Transition Program (TTP), and prepares the successful candidates for entry into MA 1116 or 1118.

MA 1070 Vectors and Matrices (3-2).
Solving systems of linear algebraic equations: Gaussian elimination, pivotal condensation. Linear independence/dependence of systems. Matrix algebra. Eigenvalues and eigenvectors for matrices. Applications using microcomputers. *Graded on a Pass/Fail basis only.*

MA 1080 Differential Calculus of a Single Variable (3-2).
Slope of a curve, derivative, velocity and other rates of change. Limits and continuity. Differentiation of products, powers, and quotients; the chain rule. Implicit differentiation. Tangent line approximation and Newton's method. Derivatives of trigonometric functions. Curve sketching, related rates, maxima, the Mean Value Theorem. Graded on a Pass/Fail basis only.

MA 1081 Integral Calculus of a Single Variable (3-2).
Indeterminate forms and L'Hopital's rule. Indefinite integrals and the Fundamental Theorem. Area under a curve, trapezoidal/ Simpson's rules. Integration by substitution. Applications to motion along a straight line, volumes, arc length, work, moments and center of mass. Calculus of inverse trigonometric, logarithmic, and exponential functions and their applications. Graded on a Pass/Fail basis only.

MA 1082 Integration Methods and Vectors (3-2).
Integration by parts, products and powers of trig functions, trig substitutions, partial fractions. Improper integrals. Hyperbolic functions. Polar coordinates. Vectors in the plane and space. Parametric equations. Lines and planes in space. *Graded on a Pass/Fail basis only.*

MA 1083 Vector Functions/Introductory Differential Equations (3-2).
Vector-valued functions, tangent vectors, tangential and normal components of acceleration, curvature and arc length in space.

Applications to planetary motion. First order differential equations: separable variables, homegeneous, linear, and exact equations. Second order differential equations with constant coefficients: homogeneous and nonhomogeneous, undetermined coefficients, variation of parameters. Picard's method and Euler's method for numerical solutions. *Graded on a Pass/Fail basis only.*

Lower Division Courses

MA 1110 Introduction to the TI-59 Programmable Calculator (2-0).
Numerical calculations and basic programing on the TI-59 programmable calculator. Numerical calculations include use of the power and root keys, log and exponential keys, trigonometric and inverse trigonometric keys, and scientific and floating point notation. Basic programming includes use of the label and editing keys, read and write keys, printing, conditional and unconditional branching, loops, subroutines, use of the solid state library modules, and indirect addressing. (A TI-59 programmable calculator is required; a PC-100A printer is desirable, but not required.) *Graded on Pass/Fail basis only.*

MA 1112 Selected Calculus Topics Review (2-2).
Functions, limits, continuity, differentiation of functions of one and several variables, implicit functions, parametric equations, optimization; indefinite, definite and multiple integrals; sequences and series, series representation of functions; Euler's formula; review of complex numbers. PREREQUISITE: A previous course in calculus.

MA 1115 Single Variable Calculus (5-0).
Review of analytic geometry and trigonometry, functions of one variable, limits, derivatives, continuity and differentiability; differentiation of algebraic, trigonometric, logarithmic and exponential functions with applications to maxima and minima, rates, differentials; product rule, quotient rule, chain rule; antiderivatives, integrals and the fundamental theorem of calculus; definite integrals, areas, lengths of curves and physical applications; special methods of integration. PREREQUISITE: Precalculus mathematics *(May be taken through Continuing Education as mini-courses MA 1131-36).*

MA 1116 Multivariable Calculus (5-0).
Review of calculus of one variable; vector algebra and calculus, directional derivative, gradient and integral theorems; maxima and minima of functions of two independent variables, total differential; double and triple integrals, cylindrical and spherical coordinate systems; infinite series, convergence tests, uniform convergence and Taylor series. PREREQUISITE: Previous course in calculus. *(May be taken through Continuing Education as mini-courses MA 1137-40 and 1150.)*

MA 1117 Single Variable Calculus with Laboratory (5-2).
All of the course material of MA 1115 with an additional 2 hour problem solving laboratory. PREREQUISITE: Precalculus mathematics *(May be taken through Continuing Education as mini-courses MA 1131-36).*

MA 1118 Multivariable Calculus with Laboratory (5-2).
All of the course material of MA 1116 with an additional 2 hours problem solving laboratory. PREREQUISITE: Previous course in calculus *(May be taken through Continuing Education as mini-courses MA 1137-40 and MA 1150).*

Upper Division Courses

MA 2025 Logic, Sets and Functions (4-1).
Propositional logic, elements of set theory, relations, functions and partitions. An introduction to theorem proving techniques, including mathematical induction, in the context of basic mathematical systems.

MA 2042 Linear Algebra (4-0).
Systems of linear equations, matrices, and determinants. Finite dimensional vector spaces, linear dependence, basis, dimension, inner products, orthogonalization. Linear transformations, rank and nullity, change of basis, linear functionals, orthogonal transformations, quadratic forms, symmetric matrices, diagonalization, eigenvalues and eigenvectors. PREREQUISITES: MA 1115.

MA 2047 Linear Algebra and Vector Analysis (4-0).
Solutions of linear systems of equations, algebra of matrices, determinants. Linear vector spaces, linear dependence and independence, subspaces, bases and dimension.

Inner products, ortho-normal bases and Gram-Schmidt process. Eigenvectors and eigenvalues. The algebra and calculus of vectors in R^2 and R^3. Del operator, directional derivative, gradient, divergence and curl with applications. Line, surface and volume integrals, Green's Stoke's and divergence theorems. PREREQUISITE: MA 1116 (may be taken concurrently).

MA 2049 Applied Mathematics for Engineering and Operational Analysis (4-0).
Solutions of systems of linear algebraic equations, Gaussian elimination, pivotal condensation; matrix algebra, determinants, independent systems, eigenvalues, eigenvectors. Linear, constant coefficient ordinary differential equations, scalar and systems, homogeneous and non-homogeneous; solutions by formula, by Laplace Transforms, and by infinite series. PREREQUISITE: MA 1116 (May be taken concurrently).

MA 2050 Applied Mathematics for Engineering and Operational Analysis Plus Lab (4-1).
Course identical to MA 2049 plus a one (1) hour problem solving lab.

MA 2110 Multivariable Calculus (4-0).
Integrated with linear algebra. Functions of several variables, continuous transformations, jacobians, chain rule, implicit function theorem, inverse function theorem, extrema, Lagrange multiplier technique, curvilinear coordinates. PREREQUISITE: MA 1116 or equivalent, MA 2042 or equivalent concurrently.

MA 2121 Differential Equations (4-0).
Ordinary differential equations: linear and non-linear equations, homogeneous and nonhomogeneous equations, linear independence of solutions, power series solutions, systems of differential equations, Laplace transforms applications. PREREQUISITE: MA 1116 or equivalent, MA 2047 or equivalent concurrently.

MA 2125 Differential Equations (3-0).
An abbreviated version of MA 2121, without Laplace transforms. PREREQUISITE: MA 1116 or equivalent, MA 2047 or equivalent concurrently.

MA 2129 Ordinary Differential Equations and Laplace Transforms (2-1).
First order ordinary differential equations, second order equations with constant coefficients, application, Laplace transforms. PREREQUISITE: Differential and integral calculus.

MA 2151 Introduction to Complex Variables and Numerical Methods (4-0).
Analytic functions, Laplace's equation, rational functions; line integrals in the plane, Cauchy's integral theorem, indefinite integration, Cauchy's integral formula. Taylor series, finite differences, roots of equations, linear equations, numerical integration. PREREQUISITES: FORTRAN programming and MA 1116.

MA 2181 Vector Calculus (2-1).
Differentiation and integration of vector functions. The del operator and related concepts. Green's theorem, Stokes' theorem, divergence theorem. Interpretations and applications. PREREQUISITE: Calculus and vector algebra.

MA 2300 Mathematics for Management (5-0).
This course is designed to provide a mathematical basis for modern managerial tools and techniques. It includes elements of differential and integral calculus, sequences and series and an introduction to matrix algebra. PREREQUISITE: College algebra.

MA 2400 Introduction to Vectors, Matrices and Vector Calculus (3-0).
The algebra of vectors and matrices. Systems of linear equations, determinants; eigenvalues. Directional derivative, gradient, divergence, curl; line, surface and volume integrals; integral theorems; applications. PREREQUISITE: Differential and integral calculus.

MA 2401 Introduction to Differential Equations and Complex Functions (4-1).
Ordinary differential equations including series solutions and Laplace transforms; Fourier series and partial differential equations; complex analytic functions. PREREQUISITE: Differential and integral calculus.

MA 3001 Incremented Directed Study (1-0).
This course provides the opportunity for a student who is enrolled in a three thousand level course to pursue the course material in greater depth by directed study to the extent of one additional hour beyond the normal course credit.

MA 3002 Incremented Directed Study (2-0).
This course provides the opportunity for a student who is enrolled in a three thousand level course to pursue the course material in greater depth by directed study to the extent of two additional hours beyond the normal course credit.

MA 3026 Discrete Mathematics and Automata Theory (5-0).
Analysis of algorithms. Elementary concepts of semigroups, monoids, and groups. Regular languages and finite state automata. Context-free languages and push-down automata. Applications to computer science. PREREQUISITE: MA 2025.

MA 3035 Mathematical Introduction to Microprocessors (2-1).
An introduction to microprocessors at the hardware/software interface. Machine language programming, assembly language programming, connecting and controlling peripherals (terminal, disc drive...), operating systems.

MA 3046-3047 Linear Algebra I-II (3-0).
Special types of matrices; orthogonal reduction of a real symmetric matrix to diagonal form; quadratic forms and reductions to expressions involving only squares of the variables; applications to maxima and minima; Lambda matrices and related topics; Cayley-Hamilton theorem. Reduced characteristic function; canonical forms, idempotent and nilpotent matrices; solutions to matrix polynomial equations; functions of a square matrix; applications such as to differential equations, stability criteria. PREREQUISITE: MA 2042.

MA 3132 Partial Differential Equations and Integral Transforms (4-0).
Solution of boundary value problems by separation of variables; Sturm-Liouville problems; Fourier, Bessel and Legendre series solutions, Laplace and Fourier transforms; classification of second order equations; applications. PREREQUISITE: MA 2121 or equivalent.

MA 3139 Fourier Analysis and Partial Differential Equations (4-0).
Solution of the one-, two-, and three-dimensional wave equations by separation of variables and characteristics; d'Alembert's solution; ray propagation; Fourier analysis applied to ordinary and partial differential equations; convolution theorems. *For ASW students.* PREREQUISITE: MA 2129.

MA 3185 Tensor Analysis (3-0).
Definition of tensor. Algebra of tensors. The metric tensor. The geometric representation of vectors in general coordinates. The covariant derivative and its application to geodesics. The Riemann tensor, parallelism, and curvature of space. PREREQUISITE: Consent of Instructor.

MA 3232 Numerical Analysis (3-2).
Solution of nonlinear equations, zeros of polynomials. Interpolation and approximation. Numerical differentiation and quadrature. Matrix manipulations; linear simultaneous algebraic equations, eigenvalues. Numerical solutions of ordinary differential equations. Analysis for computational errors. PREREQUISITE: MA 2121 or equivalent (may be taken concurrently) and FORTRAN programming.

MA 3243 Numerical Methods for Partial Differential Equations (4-1).
Finite difference approximations for derivatives. Truncation and discretization errors. Parabolic and hyperbolic equations. Explicit and implicit methods. The Crank-Nicolson method. Approximations at irregular boundaries. Elliptic equations, the Liebmann method. Systems of partial differential equations. Students are expected to write FORTRAN programs for the above methods. PREREQUISITE: MA 3132 and FORTRAN programming.

MA 3362 Orbital Mechanics (3-0).
Review of kinematics, Lagrange's equation of motion. The earth's gravitational field. Central force motion. The two body problem. Perturbations. PREREQUISITE: Consent of Instructor.

MA 3400 Mathematical Modeling Processes (3-0).
Practice model construction while demonstrating the utility and universality of mathematics. Topics include modeling using graphical analysis, the model building process, modeling using proportionality, analysis of data, modeling using dimensional

analysis, dynamical models, optimization of models and simulation. PREREQUISITE: MA 1116 or MA 2300 or consent of Instructor.

MA 3560 Modern Applied Algebra (3-0).
An introductory course in the techniques and tools of abstract algebra with special emphasis on applications to coding theory, radar and communications systems and computer science. Elements of set theory, equivalence relations and partitions. Semigroups, groups, subgroups and homomorphisms. Rings, ideals and fields. Directed graphs and lattices. Applications may vary. PREREQUISITE: Consent of Instructor.

MA 3565 Modern Algebra I (3-0).
An advanced course in the subject of abstract algebra. Semigroups, groups, subgroups, normal subgroups. Groups acting on sets, operator groups. The Jordan-Holder Theorem, solvable groups. The Krull Schmidt Theorem. PREREQUISITE: MA 3560 or consent of Instructor.

MA 3605-3606 Fundamentals of Analysis I-II (3-0).
Elements of set theory, the real number system, and the usual topology of En; properties of continuous functions; differential of vector-valued functions, Jacobians, and applications (implicit function, inverse function theorem, extremum problems). Functions of bounded variation and theory of Reimann-Stieltjes integration, multiple and iterated integrals, convergence theorems for sequences and series of functions. PREREQUISITE: Consent of Instructor.

MA 3610 Introduction to General Topology (3-0).
Topologies, bases and subbases, compactness and connectivity. Moore-Smith convergence theorems. Metrization and embedding theorems, uniform structures. Tychonoff product theorem, Alexandroff and Stone Cech compactification. PREREQUISITE: MA 3605.

MA 3675-3676 Theory of Functions of a Complex Variable I-II (3-0).
Selected topics from the theory of functions of a real variable; complex functions, power series, Laurent series. Singularities of complex functions; residues and contour integration; zeros of analytic functions, factors of and infinite product representation for analytic functions; maximum modulus theorems for analytic and harmonic functions; conformal mapping. PREREQUISITE: Consent of Instructor.

MA 3730 Theory of Numerical Computation (3-0).
Analysis of computational methods used for the solution of problems from the areas of algebraic equations, polynomial approximation, numerical differentiation and integration, and numerical solution of ordinary differential equations. PREREQUISITE: Consent of Instructor.

Graduate Courses

MA 4237 Advanced Topics in Numerical Analysis (Variable credit, usually (4-0)).
The subject matter will vary according to the abilities and interest of those enrolled. PREREQUISITE: Consent of Instructor. *Graded on Pass/Fail basis only.*

MA 4391-4392 Numerical Methods for Fluid Dynamics I-II (4-0).
Analytical methods used to study potential, inviscid and viscous flows will be considered in the first quarter. Numerical methods for the solution of the same problems will be exclusively used during the second quarter. PREREQUISITES: MA 2129, MA 2151 or MA 2401; MA 3132 or MA 3139.

MA 4393 Topics in Applied Mathematics (3-0).
A selection of topics in applied mathematics. The course content varies. Credit may be granted for taking this course more than once. PREREQUISITE: Consent of Instructor.

MA 4566 Modern Algebra II (3-0).
A continuation of MA 3365. Rings, ring homomorphism, integral domains and euclidean domains. Unique factorization rings, polynominal rings. Modules and ideals. Noetherian rings, Field extension and Galois theory. PREREQUISITE: MA 3565.

MA 4593 Topics in Algebra (3-0).
A selection of topics in algebra. Content of the course varies. Students will be allowed credit for taking the course more than once. PREREQUISITE: Consent of Instructor. *Graded on Pass/Fail basis only.*

MA 4611 Calculus of Variations (3-0).
Euler equation, Weierstrass maximum principle, Legendre condition, numerical procedures for determining solutions, gradient methods, Newton's method, transversality condition, Rayleigh-Ritz method, conjugate points, and applications. PREREQUISITE: MA 2121 (programming experience desirable).

MA 4620 Theory of Ordinary Differential Equations (3-0).
Introduction to the modern theory of ordinary differential equations. Systems of equations. Theoretical and constructive methods of solutions. PREREQUISITE: Consent of Instructor.

MA 4622-4623 Principles and Techniques of Applied Mathematics I-II (3-0).
Linear operators, generalized functions and Hilbert spaces; solutions of partial differential equations by eigenfunctions; variational techniques and their applications to eigen functions; integral equations, Laplace, Fourier and other transforms, including their inversion in the complex plane as applied to partial differential equations; method of characteristics for hyperbolic equation. PREREQUISITE: MA 3132 or equivalent.

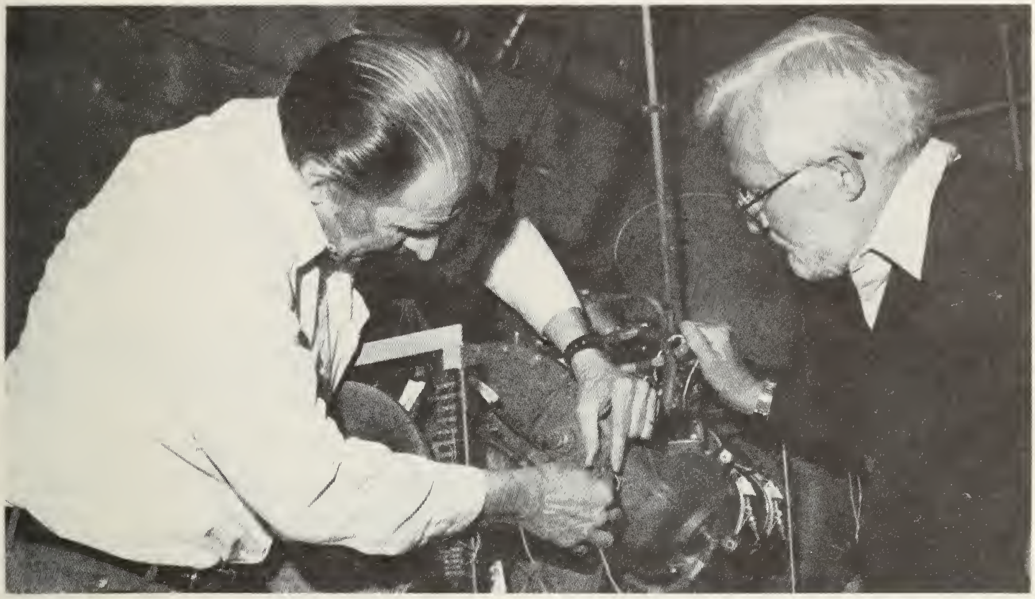
MA 4635-4636 Functions of Real Variables I-II (3-0).
Semi-continuous functions, absolutely continuous functions, functions of bounded variation; classical Lebesque measure and integration theory, convergence theorems and Lp spaces. Abstract measure and integration theory, signed measures, Radon-Nikodym theorem; Lebesque decomposition and product measure; Daniell integrals and integral representation of linear functionals. PREREQUISITE: MA 3606.

MA 4672 Integral Transforms (3-0).
The Laplace, Fourier and Hankel transforms and their inversions. Applications to problems in engineering and physics. PREREQUISITE: MA 2172.

MA 4693 Topics in Analysis (3-0).
A selection of topics in analysis. Content of the course varies. Students will be allowed credit for taking the course more than once. PREREQUISITE: Consent of Instructor.

MA 4872 Topics in Calculus of Variations (3-0).
Recent development of the numerical solution of problems in the calculus of variations. Foundations of numerical methods, applications to control problems. Differentials, perturbations, variational equations, adjoint system, conditions for optimum. Euler equations, maximum principle of Weierstrass and Pontryagin, the Legendre condition. Methods of solution: special variations, variation of extremals, dynamic programming. Applications in ship routing and missile control. PREREQUISITES: MA 2121 and computer programming or Consent of Instructor.

DEPARTMENT OF MECHANICAL ENGINEERING



Professors Pucci and Kelleher adjusting the instrumentation on the gas turbine engine combustor

Paul James Marto, Professor of Mechanical Engineering; Chairman (1965)*; B.S., Univ. of Notre Dame, 1960; S.M., in Nuc. Engr., Massachusetts Institute of Technology, 1962; Sc.D., 1965.

Kenji Adachi, Adjunct Research Professor of Mechanical Engineering (1983); B.S., Hokkaido Univ., Japan, 1976; M.S., 1978; Ph.D., Univ. of Illinois, 1983.

Donald Herbert Boone, Adjunct Research Professor of Mechanical Engineering (1980); B.S., Univ. of Illinois, 1957; M.S.MET.E., 1959; Ph.D., 1962.

Gilles Cantin, Professor of Mechanical Engineering (1960); B.A. Sc., Ecole Polytechnique at Montreal, 1950; M. Sc., Stanford Univ., 1960; Ph.D., Univ. of California at Berkeley, 1968.

Kenneth David Challenger, Associate Professor of Materials Science (1979); B.S.MET.E., Univ. of Cincinnati, 1967; M.S.MET.E., 1971; Ph.D., 1973.

William Gene Culbreth, Assistant Professor of Mechanical Engineering (1981); B.S., California Polytechnic State Univ. at Pomona, 1975; M.S., Univ. of California at Santa Barbara, 1978; Ph.D., 1981.

Prabir Deb, Adjunct Research Professor of Mechanical Engineering (1983); B.E., Univ. of Calcutta, 1973; M.Tech, I.I.T. Kanpur, India, 1976; Ph.D., 1980.

David Vernon Edmonds, Adjunct Professor of Materials Science (1985); B.Sc. Univ. of Birmingham, 1965; Ph.D. in Physical Metallurgy, 1968; M.A., Univ. of Cambridge, 1971; M.A. Univ. of Oxford, 1979.

Michael E. Kassner, Adjunct Professor of Mechanical Engineering (1984); BSSE, Northwestern Univ., 1972; MS. Met.E., Illinois Institute of Technology, 1977; M.S., Stanford Univ., 1979; Ph.D., 1981.

Matthew Dennis Kelleher, Professor of Mechanical Engineering (1967); B.S., Univ. of Notre Dame, 1961; M.S.M.E., 1963, Ph.D., 1966.

Allan D. Kraus, Adjunct Professor of Mechanical Engineering (1983); B.S., Yale Univ., 1946; MSME, Columbia Univ., 1949; M.E.E., Brooklyn Polytechnic Institute, 1958; Ph.D., Univ. of South Florida, 1976.

Eui Whee Lee, Adjunct Research Professor of Mechanical Engineering (1984); B.S., Seoul Univ., 1977; M.S., Georgia Institute of Technology, 1980; Ph.D., 1982.

Phillip Meredith Ligrani, Associate Professor of Mechanical Engineering (1984); B.S., Univ. of Texas at Austin, 1974; M.S.M.E., Stanford Univ., 1975; Ph.D., 1980.

Terry Robert McNelley, Associate Professor of Materials Science (1976); B.S.Met.E., Purdue Univ., 1967; Ph.D., Stanford Univ., 1973.

Robert Eugene Newton, Professor of Mechanical Engineering (1951); B.S.M.E., Washington Univ., 1938; M.S., 1939; Ph.D., Univ. of Michigan, 1951.

Robert Harry Nunn, Professor of Mechanical Engineering (1968); B.S., Univ. of California at Los Angeles, 1955; M.S.M.E., 1964; Ph.D., Univ. of California at Davis, 1967.

Arthur Jeffery Perkins, Professor of Materials Science (1972); B.S., Drexel Institute of Technology, 1965; M.S., Case Institute of Technology, 1967; Ph.D., in Metallurgy, Case Western Reserve Univ., 1969.

Paul Francis Pucci, Professor of Mechanical Engineering (1956); B.S., Purdue Univ., 1949; M.S.M.E., 1950; Ph.D., Stanford Univ., 1955.

John Winston Rose, Adjunct Research Professor of Mechanical Engineering (1983); B.Sc., Univ. of London, 1958; Ph.D., 1964; D.Sc., 1979.

David Salinas, Associate Professor of Mechanical Engineering (1970); B.S., Univ. of California at Los Angeles, 1959; M.S., 1962; Ph.D., 1968.

Turgut Sarpkaya, Distinguished Professor of Mechanical Engineering (1967); B.S.M.E., Tech. Univ. of Istanbul, 1950; M.S.M.E., 1951; Ph.D., Univ. of Iowa, 1954.

Young Sik Shin, Associate Professor of Mechanical Engineering (1981); B.S., Seoul National Univ., 1965; M.S., Univ. of Minnesota, 1966; Ph.D., Case Western Reserve Univ., 1971.

David L. Smith, Associate Professor of Mechanical Engineering (1983); B.S., Oklahoma State Univ., 1971; M.S., 1972; Ph.D., 1979.

Amarawansa S. Wanniarachchi, Adjunct Research Professor of Mechanical Engineering (1983); B.S., Univ. of Sri Lanka, Sri Lanka, 1975; M.S., Pennsylvania State Univ., 1979; Ph.D., 1981.

Kwang Tzu Yang, NAVSEA Research Chair Professor of Mechanical Engineering (1985); B.S., Illinois Institute of Technology, (1951); M.S., 1952; Ph.D., 1955.

Emeritus Faculty

Roy Walters Prowell, Professor Emeritus (1946); B.S. in I.E., Lehigh Univ., 1936; M.S.M.E., Univ. of Pittsburgh, 1943.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN MECHANICAL ENGINEERING

A specific curriculum must be consistent with the general minimum requirements for the degree as determined by the Academic Council.

Any program leading to award of a degree must be approved by the Chairman of the Department of Mechanical Engineering at least two quarters before completion. In general, approved programs will require more than minimum degree requirements in order to conform to the needs and objectives of the United States Navy.

MASTER OF SCIENCE IN MECHANICAL ENGINEERING

Undergraduate Preparation. A candidate shall have completed work equivalent to the Bachelor of Science requirements of this department. Candidates who have minor deficiencies, or who would like to review their undergraduate material, may utilize the NPS Continuing Education Program which offers a variety of courses in the self-study mode. Candidates who have not majored in Mechanical Engineering, or who have experienced a significant lapse in continuity with previous academic work, initially will take undergraduate courses in mechanical engineering and mathematics in preparation for their graduate program.

Approved Curriculum. The candidate must take all courses in a curriculum approved by the Chairman of the Department of Mechanical Engineering. At minimum, the approved curriculum must satisfy the requirements below.

Required Courses. The Master of Science degree in Mechanical Engineering requires at least 32 quarter hours of graduate level credits in Mechanical Engineering and Materials Science, at least 10 of which must be at the 4000 level. In addition, at least 8 quarter hours of graduate credit must be earned outside of Mechanical Engineering and Materials Science.

Thesis. An acceptable thesis is required for the Master of Science in Mechanical Engineering degree. An acceptable thesis for the degree of Mechanical Engineer may also be accepted as meeting the thesis requirement for the Master's degree. Approval of the thesis topic must be obtained from the Chairman of the Department of Mechanical Engineering. An advisor will be appointed by the Chairman of the Department of Mechanical Engineering for consultation in the development of a program of research.

MASTER OF SCIENCE IN ENGINEERING SCIENCE

Students with acceptable academic backgrounds may enter a program leading to the degree Master of Science in Engineering Science (with major in Mechanical Engineering).

The program must include at least 36 credit hours of graduate work in the disciplines of engineering, science and mathematics, 12 of which must be at the 4000 level. Of these 36 hours, at least 20 hours (8 of which must be at the 4000 level) must be in Mechanical Engineering and Materials Science.

In addition, the program must contain at least 12 hours at the graduate level in courses outside Mechanical Engineering and Materials Science.

The student seeking the degree Master of Science in Engineering Science must submit an acceptable thesis. Programs leading to this degree must be approved by the Chairman of the Department of Mechanical Engineering.

MECHANICAL ENGINEER

A graduate student with a superior academic record may enter a program leading to the degree Mechanical Engineer. A candidate is normally selected

after completion of his first year of residence.

The candidate must take all courses in a curriculum approved by the Chairman of the Department of Mechanical Engineering. At minimum, the approved curriculum must satisfy the requirements stated in the paragraphs below.

The Mechanical Engineer degree requires at least 60 quarter hours of graduate level credits in Mechanical Engineering and Materials Science, at least 30 of which must be at the 4000 level. In addition, at least 12 quarter hours of graduate level credits must be earned outside of Mechanical Engineering and Materials Science. At least 30 of the above required graduate level credits within the department must be at the 4000 level.

An acceptable thesis is required for the Mechanical Engineer degree. Approval of the thesis program must be obtained from the Chairman of the Department of Mechanical Engineering. An advisor will be appointed by the Chairman of the Department of Mechanical Engineering for consultation in the development of a program of research.

DOCTOR OF PHILOSOPHY AND DOCTOR OF ENGINEERING

The Department of Mechanical Engineering has an active program leading to the degrees of Doctor of Philosophy and Doctor of Engineering. Areas of special strength in the department are hydrodynamics, viscous flows, heat transfer, materials science, structural mechanics, and finite element analysis.

Joint programs with other departments are possible. A noteworthy feature of the program leading to the Doctor of Engineering degree is that the student's research may be conducted away from the Naval Postgraduate School in a cooperating laboratory or other installation of the Federal Government. The degree requirements are as outlined in the general school requirements for the Doctor's degree.

MECHANICAL ENGINEERING LABORATORIES

The Mechanical Engineering Laboratories are designed as complements to the educational mission and research interests of the department. In addition to the extensive facilities for the support of student and faculty research, a variety of general use equipment is available. This includes machinery for the investigation of dynamic and static problems in engineering mechanics; a completely equipped materials science laboratory, including a scanning electron microscope; a transmission electron microscope and an x-ray diffractometer; an oscillating water tunnel, a unique underwater towing tank and a low turbulence water channel; a vibration analysis laboratory; facilities for experimentation with low velocity air flows; equipment for instruction in thermal transport phenomena; a laser doppler velocimeter; nuclear radiation detection equipment; and an interactive computer graphics laboratory. Experimentation is further enhanced by a broad selection of analog and digital data acquisition and processing equipment and instrumentation.

DEPARTMENTAL COURSE OFFERINGS

MECHANICAL ENGINEERING

ME/MS 0810 Thesis Research (0-0).
Every student conducting thesis research will enroll in this course.

ME 0951 Seminars (0-1).
Lectures on subjects of current interest are presented by NPS faculty and invited experts from other universities and government and industrial activities.

Lower Division Course

ME 1000 Preparation for Professional Engineers Registration (3-0).
The course will cover the topics from the 8-hour Professional Examination given by the State of California for Professional Engineer. Discussion will involve applicable engineering techniques, including design and analysis of mechanical systems and components. PREREQUISITES: Prior passage of EIT Exam or consent of Instructor. *Graded on Pass/Fail basis only.*

Upper Division Courses

ME 2001 Introduction to Engineering (3-0).
The origins of engineering. The role of mathematics and the physical sciences in engineering. Definition of an engineering problem, including its formulation, assumptions and method of attack. Engineering analysis. The engineering design process. Engineering communications, including graphics. This course is intended for students with a non-engineering background. PREREQUISITE: MA 1115 (may be taken concurrently).

ME 2101 Engineering Thermodynamics (4-1).
A comprehensive coverage of the fundamental concepts of classical thermodynamics, with insight toward microscopic phenomena. The laws of thermodynamics. Equations of state. Thermodynamic properties of substances. Entropy, irreversibility and availability. Cycle analysis. Gas-vapor mixtures. Combustion and dissociation. PREREQUISITE: MA 1116. *(May be taken through Continuing Education as mini-courses ME 2111-15.)*

ME 2201 Introduction to Fluid Mechanics (3-2).
Properties of fluids. Hydrostatics and stability of floating and submerged bodies. Fluid flow concepts and basic equations in steady flows: mass, momentum, and energy considerations. Dimensional analysis and dynamic similitude. Viscous effects and fluid resistance. Drag and separated flow over simple bluff bodies. Emphasis on naval engineering applications and problem solving. PREREQUISITE: ME 2502.

ME 2301 Introduction to Naval Architecture (4-0).
Introduction to the hydrostatics and hydrodynamics of a monohull vessel. Hull structural strength using simple approximations and common ship building materials. Intact initial transverse and longitudinal stability. Stability at large angles of heel and under special circumstances such as docking and after damage to the hull. Resistance and powering of the hull; determination of effective horsepower. PREREQUISITES: ME 2201 and ME 2601.

ME 2410 Mechanical Engineering Lab I (2-3).
Fundamentals of mechanical measurement systems, structured laboratory experiments using resistance strain gages, pressure transducers, temperature, flow and velocity measurement devices. PREREQUISITES: ME 2101, ME 2201, and ME 2601, any of which may be taken concurrently. *Graded on Pass/Fail basis only.*

ME 2440 Modern Methods of Engineering Computation (3-0).
Formulation and solution of engineering problems using modern computers. Introduction to high-level programming languages including FORTRAN and BASIC. Development of computer programs including flowcharting, data transfer, subroutine organization, input and output. Application of programming techniques to the solution of selected problems in Mechanical Engineering. PREREQUISITES: MA 1116, ME 2101, ME 2501 (all may be taken concurrently) ME 2441 (must be taken concurrently).

ME 2441 Engineering Computational Laboratory (0-2).
Introduction to the computing facilities at the Naval Postgraduate School with particular emphasis on those unique to the Department of Mechanical Engineering. Familiarization with software available at the Naval Postgraduate School for solution of engineering problems. Various programming exercises. (ME 2440 must be taken concurrently). *Graded on a Pass/Fail basis only.*

ME2501 Statics (3-0).
Forces and moments, particles and rigid bodies in equilibrium. Simple structures, friction, first moments and centroids. PREREQUISITE: MA 1116 (may be oncurrent). *May be taken through Continuing Educations as mini-courses ME 2511-13.)*

ME 2502 Dynamics (4-1).
Kinematics and kinetics of particles and rigid bodies. Rectilinear, plane curvilinear and space curvilinear motion. Newton's laws, work and energy, impulse and momentum, and impact. Plane motion of rigid bodies and introduction to gyroscopic motion. PREREQUISITE: ME 2501.

ME 2601 Mechanics of Solids (3-2).
Stress, strain, Hooke's law. Elementary stress and deformation analysis for shafts, beams and columns. Supporting laboratory work. PREREQUISITES: ME 2501 and MA 1116.

Upper Division or Graduate Courses

ME 3003 Energy and the Environment (3-0).
Principles of energy technology. Supply and demand. Survey of resources including coal, oil, gas, and uranium fuels. Solar energy utilization. Energy conversion schemes. Conservation efforts in the Navy. Effect of energy utilization upon the environment. This is an elective course for non-M.E. majors.

ME 3150 Heat Transfer (4-2).
Elementary treatment of the principles of Heat Transfer application to problems in Mechanical Engineering. Steady and unsteady conduction. Principles of forced and natural convection. Thermal radiation. Boiling. Condensation. Heat exchanger analysis. Use of the thermal circuit analog numerical and graphical techniques. Selected laboratory experiments. PREREQUISITES: ME 2101, ME 2201, MA 3132 (may be taken concurrently).

ME 3201 Intermediate Fluid Mechanics (3-2).
Steady one-dimensional compressible flow. Fundamentals of ideal-fluid flow, potential function, stream function. Analysis of viscous flows, velocity distribution in laminar and turbulent flows, introduction to the elements of the Navier-Stokes equations, solution of classical viscous laminar flow problems. Boundary-layer concepts. PREREQUISITES: ME 2101, ME 2201, MA 3132 (may be taken concurrently).

ME 3220 Steam Power, Refrigeration, and Turbomachinery (3-2).
The conventional Rankine cycle steam plants, including superheat, reheat, and regenerative cycles. Boiler, condenser, and feed-water heater description. Thermodynamics of refrigeration systems. Fundamentals of turbomachinery: energy and momentum equations, dimensional analysis, and velocity diagrams. Application to pumps, fans, compressors, and turbines. PREREQUISITES: ME 2101 and ME 2201.

ME 3230 Nuclear Power Systems (4-0).
Introduction to atomic and nuclear physics. Fundamentals of nuclear reactor analysis, including nuclear and thermal aspects in core design. Reactor system design and operation. Comparison of principal reactor types emphasizing significant features of marine reactors. Basic health physics considerations and reactor shielding. Basic insight into waste management and reactor safety. PREREQUISITE: ME 3150.

ME 3240 Reciprocating and Gas Turbine Power Plants (3-0).
Thermodynamic analyses and performance characteristics of spark ignition engines (Otto Cycle), compression ignition engines (diesel cycle), and gas turbine engines (Brayton cycle). Gas turbine component characteristics including the aerodyn amics of the compressor and turbine design, and the combustor. Ship propulsion requirements, propeller characteristics, and Ship/Propeller/Power Plant matching. PREREQUISITES: ME 3220. (ME 3241 must be taken concurrently.)

ME 3241 Power Plants Laboratory (0-3).
Selected experiments demonstrating power plant performance, e.g., diesel engine, and gas turbine engine. (ME 3240 must be taken concurrently.) *Graded on Pass/Fail basis only.*

ME 3430 Mechanical Engineering Lab II (1-3).
A project-oriented continuation of mechanical measurement systems. Application of measurement techniques using group projects in thermodynamics, mechanics of solids, heat transfer, fluid flow, vibrations and nuclear radiation detection. PREREQUISITES: ME 2410, ME 3150, ME 3521, and ME 3611. *Graded on Pass/Fail basis only.*

ME 3440 Engineering Analysis (4-0).
Rigorous formulation of engineering problems arising in a variety of disciplines. Approximate methods of solution. Finite Difference methods. Introduction to Finite Element methods. PREREQUISITES: ME 2201, ME 2440, ME 2502, and ME 2601.

ME 3521 Mechanical Vibration (3-2).
Free and forced vibration of discrete linear systems. Vibration isolation and suppression. Vibration of bars, shafts, and beams. Supporting laboratory work. PREREQUISITES: ME 2502, ME 2601, and MA 2401 or equivalent (may be taken concurrently).

ME 3611 Mechanics of Solids II (4-0).
Fundamentals of elasticity. Failure theories. Energy methods. Indeterminate structures. Stability of simple structures. Torsion of members with non-circular cross section. Plate behavior. PREREQUISITES: ME 2601 and MA 2401 or equivalent (may be taken concurrently).

ME 3711 Design of Machine Elements (4-1).
Design of representative machine elements with consideration given to materials selection, tolerances, stress concentrations, fatigue, factors of safety, reliability, and maintainability. Typical elements to be designed include fasteners, columns, shafts, journal bearings, spur and helical gears, and clutches and brakes. In addition to traditional design using factors of safety against failure, particular emphasis is placed on design for specified reliability using probabilistic design methods. PREREQUISITES: ME 2410 and ME 2601.

ME 3801 Linear Automatic Control (3-2).
Classical control design for linear systems with single input, single output design requirements. Mathematical modeling of mechanical systems. Transient response analysis. Root locus and frequency response methods. Control design and compensation techniques. PREREQUISITES: MA 2121 and ME 2502.

Graduate Courses

ME 4160 Applications of Heat Transfer (4-0).
Application of heat transfer principles to engineering systems. Topics include heat exchangers (e.g., boilers, condensers, coolers), cooling electronic components, heat pipes, solar collectors, turbine blade cooling. PREREQUISITE: ME 3150.

ME 4161 Conduction Heat Transfer (4-0).
Steady-state heat conduction in multi-dimensions with and without heat sources. Transient conduction. Numerical methods for heat conduction. Variational methods. Mechanical Engineering applications. PREREQUISITE: ME 3150.

ME 4162 Convection Heat Transfer (4-0).
Fundamental principles of forced and free convection. Dimensionless correlations. Heat transfer during phase changes. Combined conduction, convection and radiation heat transfer systems. Heat exchanger analysis with Mechanical Engineering applications. PREREQUISITES: ME 3150, ME 4220.

ME 4163 Radiation Heat Transfer (3-0).
Basic laws and definitions. Radiation properties of surfaces. Radiant interchange among diffusely emitting and reflecting surfaces. Applications and solutions of the equations of radiant interchange. Radiant interchange through participating media. Combined conduction and radiation. Combined convection and radiation. Spectral aspects of gases. PREREQUISITE: ME 3150.

ME 4202 Compressible Flow (3-0).
Review of simple one-dimensional flow. Generalized one-dimensional flow. Two-dimensional and axisymmetric flows. Subsonic flow with small perturbations. Mach lines. Method of characteristics. Prandtl-Meyer expansion waves. Oblique shocks. Unsteady, one-dimensional flow. Introduction to compressible boundary layer. PREREQUISITE: ME 3201 or equivalent compressible flow coverage.

ME 4211 Applied Hydrodynamics (4-0).
Fundamental principles of hydrodynamics. Brief review of the equations of motion and types of fluid motion. Standard potential flows: source, sink, doublet, and vortex motion. Flow about two-dimensional bodies. Flow about axisymmetric bodies. Added mass of various bodies and the added-mass moment of inertia. Complex variables approach to flow about two-dimensional bodies. Conformal transformations. Flow about hydro- and aerofoils. Special topics such as dynamic response of submerged bodies, hydroelastic oscillations, etc.. Course emphasizes the use of various numerical techniques and the relationship between the predictions of hydrodynamics and viscous flow methods. PREREQUISITE: ME 3201.

ME 4215 Dynamics of Marine Vehicles (4-0).
Development of the equations of motion and their linear forms. Elements of path keeping and stability for ships and submersibles. Maneuverability. Fluid-structure interactions due to buoyancy, resistance, and propulsion. Hydrodynamics of lifting surfaces. Calculation of the hydrodynamic derivatives. Selected topics. PREREQUISITE: ME 3201.

ME 4220 Viscous Flow (4-0).
Development of continuity and Navier-Stokes equations. Exact solutions of steady and unsteady viscous flow problems. Development of the boundary-layer equations. Similarity variables, numerical and integral techniques. Separation, boundary-layer control, compressibility effects. Time-dependent boundary layers. Origin and nature of turbulence, phenomenological theories, calculation of turbulent flows with emphasis on naval engineering applications. PREREQUISITE: ME 3201.

ME 4240 Advanced Topics in Fluid Dynamics (4-0).
Topics selected in accordance with the current interests of the students and faculty. Examples include fluid-structure interactions, cable strumming, wave forces on structures, free-streamline analysis of jets, wakes, and cavities. PREREQUISITES: ME 4220 and ME 4211.

ME 4311 Nuclear Reactor Analysis (4-0).
Neutron cross sections. The fission process. Neutron transport. Slowing down and diffusion of neutrons. Criticality analysis of bare, homogeneous reactors. The influence of reflectors. Reactor kinetics and control. PREREQUISITES: ME 3230 or equivalent, MA 3132.

ME 4321 Reactor Engineering Principles and Design (4-2).
Reactor heat generation and removal. Thermal hydraulic analysis of light water reactors. Principles of reactor shielding. Materials and safety considerations in reactor design. Group design project. PREREQUISITE: ME 3230 or equivalent.

ME 4420 Marine Gas Turbines (4-0).
Thermodynamic analyses of gas turbine cycles, including airbreathing and closed cycle engines. Internal aerodynamics of compressor and turbine design. Combustor and source heat exchanger design. Materials considerations. Operational controls and instrumentation. Lubrication and fuels systems. Inlet, exhaust, and silencing systems. Propulsion of surface effect, hydrofoil, and conventional surface effect, hydrofoil, and conventional surface ships. Installation arrangements. Waste heat recovery systems and combined cycles (COGAS, CODOG). Auxiliary power generation. Repair and maintenance. PREREQUISITE: ME 3240.

ME 4512 Advanced Dynamics (3-2).
Three-dimensional kinematics. The inertia tensor. Dyadic-vector formulation of dynamical equations. Topics of special interest. PREREQUISITE: ME 3521.

ME 4522 Vibration, Noise, and Shock (4-0).
Matrix analysis of many degree of freedom systems. Discrete models of continuous systems. Transfer matrices. Applications to shipboard vibration and noise control. Shock response analysis. PREREQUISITE: ME 3521.

ME 4525 Naval Ship Shock Design and Analysis (4-0).
Characteristics of underwater explosion phenomena, including the shock wave, bubble behavior and bubble pulse loading, and bulk cavitation. Surface ship/submarine bodily response to shock loading. Application of shock spectra to component design. Dynamic Design Analysis Method (DDAM) and applications to shipboard equipment design. Fluid-Structure Interaction (FSI) analysis, including Doubly Asymptotic Approximation (DAA) and surface ship FSI. Current design requirements for shipboard equipment. PREREQUISITE: ME 3521 or equivalent.

ME 4550 Random Vibrations and Spectral Analysis (3-2).
Engineering application of spectral analysis techniques to characterize system responses under a random vibration environment. Characteristics of physical random data and physical system responses. Application of probability concepts to random data and response analysis. Correlation and spectral density functions. Transmission of random vibration. System responses to

single/multiple random excitations. Failure due to random vibration. Supporting laboratory work. PREREQUISITE: ME 3521 or equivalent.

ME 4612 Advanced Mechanics of Solids (4-0).
Selected topics from advanced strength of materials, elasticity, and the theory of plates and shells. Applications of finite element codes to the solution of difficult problems. PREREQUISITE: ME 3611.

ME 4613 Finite Element Methods (4-0).
Systematic construction of line, surface, and volume elements for continuous systems. Computer programming, and applications to structural mechanics, heat transfer and fluid flow. PREREQUISITE: ME 3611.

ME 4620 Theory of Continuous Media (4-0).
Tensor analysis. Stress and strain tensors. Motion of a continuum. Energy and entropy. Constitutive equations. Applications to elasticity and fluid dynamics. PREREQUISITES: ME 3201 and ME 3611.

ME 4721 Marine Vehicle Design (2-4).
Various categories of marine vehicles are described; this includes single hull, multiple hull, submarine, surface effect, wing-in-ground effect and hydrofoil vehicles. A category of marine vehicle is selected to fulfill a stated mission. A vehicle configuration and specification of major components which satisfies mission requirements is sought. Consideration is given to all major facets of marine vehicle synthesis including structures, hull forces, propulsion, electronics, armament, crew, etc. PREREQUISITE: ME 2301.

ME 4722 Marine Engineering Design (2-4).

A major component of a marine vehicle is designed so as to meet stated specifications. Impact of the design features of the major component upon the overall vehicle performance is considered; emphasis is on design tradeoffs. Examples of major components to be designed include complete electrical power generation and distribution system, steering, superconducting electrical motors for main propulsion, bulbous bow for sonar, armor protection of CIC, etc. PREREQUISITE: Consent of Instructor.

ME 4731 Engineering Design Optimization (4-0).
Application of automated numerical optimization techniques to design of engineering systems. Algorithms for solution of nonlinear constrained design problems. Familiarization with available design optimization programs. State-of-the-art applications. Solution of a variety of design problems in mechanical engineering, using numerical optimization techniques. PREREQUISITES: ME 3150, ME 3201, ME 3611, ME 2440 and MA 2400, or equivalent.

ME 4801 Fluid Power Control (3-2).
Fluids and fluid flows in hydraulic systems. Analysis of pumps, motors, and control valves. Analytical methods in fluid power control systems. Hydraulic power elements. Electrohydraulic servovalves. Electrohydraulic and hydromechanical servomechanisms. Selected topics. PREREQUISITE: EE 3413 or equivalent.

ME 4802 Marine Propulsion Control Systems (3-2).
Fundamental characteristics of electropneumatic and electro-hydraulic control systems operational in both steam turbine and gas turbine powered ships. Systems analysis — controllability and stability. System design using model techniques. PREREQUISITES: ME 3201, EE 3413, and ME 3240 (may be taken concurrently).

ME 4902 Advanced Study in Mechanical Engineering (1-0 to 6-0).
Directed advanced study in mechanical engineering on a subject of mutual interest to student and staff member. May be repeated for credit with a different topic. PREREQUISITE: Permission of Department Chairman. *Graded on Pass/Fail basis only.*

MATERIALS SCIENCE

Upper Division Course

MS 2201 Engineering Materials (3-2).
The basic principles of materials science are covered with emphasis on the factors involved in control of the strength and ductility of metallic materials of Naval interest. Atomic and crystal structure are discussed and emphasis is given to microstructural control and microstructure-property relationships. Additional topics include crystalline defects, deformation processes, strengthening mechanisms and heat treatment. The

course aims to provide the student with the working vocabulary and conceptual understanding necessary to more advanced study and for communication with materials experts. PREREQUISITE: Undergraduate courses in physics and chemistry and consent of Instructor.

Upper Division or Graduate Courses

MS 3201 Materials Science and Engineering (3-2).
Fundamental principles of materials science are presented with particular emphasis on and advanced coverage of the relationship between microstructure and mechanical properties of engineering materials. The effects of atomic structure, crystal structure and microstructure on properties are presented. Crystalline defects, deformation processes, strengthening mechanisms, fracture, phase equilibria, phase transformations and methods of microstructural control are discussed and practical examples are included. The course aims at providing the engineering student with the vocabulary and conceptual understanding necessary for further study and for communicating on materials engineering topics. PREREQUISITE: Undergraduate course in chemistry and physics.

MS 3202 Failure Analysis and Prevention (3-2).
Properties, problems and failures of structural materials are studied in the context of actural case studies. Topics of interest to Naval, Aero and Weapons engineers are included. For a given case study, the cause(s) of failure are discussed, and the relevant fundamental knowledge to fully understand the observed phenomena is developed. Failures occurring by fatigue, brittle fracture and corrosion mechanisms are discussed. Failure prevention, materials developments and modern methods of materials analysis are among the many aspects that are of interest. PREREQUISITE: MS 3201 or equivalent or consent of Instructor.

MS 3304 Corrosion and Marine Environmental Degradation (3-2).
Presents the basic chemical, electrochemical, mechanical, and metallurgical factors which influence the corrosion, oxidation, and deterioration of materials. Discusses standard methods of corrosion control, such as cathodic protection coatings, cladding, alloy selection, and inhibitors; special problems encountered in unfamiliar environment. PREREQUISITE: MS 2201 or equivalent.

MS 3401 Microscopy (3-2).
Electron microscopy and other sophisticated techniques are emphasized in a coverage of modern methods of microscopic observation. Techniques covered include scanning electron microscopy, transmission electron microscopy, conventional microprobe analysis, field ion microscopy, and polarized light, stereo, interference, phase contrast, and holographic light optical methods. Course and lab will simultaneously cover both theory and practice, including specimen preparation, instrument design and operation, and applications, PREREQUISITE: Consent of Instructor.

MS 3505 Materials Selection for Military Applications (4-0).
This course deals in depth with one of the most common and important problems in materials engineering, that of selecting the optimum material for a given application. Consideration is also given to evolution of new applications for existing materials, and to materials development for new and old applications. A variety of application areas are covered, including marine structures, aerospace applications, nuclear reactors, electronics, high temperature cryogenic services, and many other situations. Sources of information, methodology, and basic rationale for materials selection decisions are presented. Emphasis is put on the variation in properties of a given material with processing history, and on variation of properties in service. PREREQUISITE: MS 2201 or equivalent.

MS 3606 Introduction to Welding and Joining Metallurgy (3-2).
Metallurgical aspects of welding and joining processes; nature of and applications of welding and joining processes; welding and joining of steels, aluminum alloys, stainless steels, heat-resistant alloys and copper-base alloys; inspection and quality assurance of weldments. PREREQUISITE: MS 2201/3201.

Graduate Courses

MS 4215 Phase Transformations (3-2).
Structural changes which commonly occur in materials by various mechanisms are considered. Solidification, precipitation, recrystallization, and martensitic transformations are emphasized, both in principle and in regard to their technological importance. Principles of nucleation and growth, diffusion and kinetics are presented and their relevance to practical heat treating and fabrication processes are considered. PREREQUISITE: MS 2201 or equivalent.

MS 4302 Special Topics in Materials Science (1-0 to 6-0).
Directed advanced study in materials science on a subject of mutual interest to student and staff member. May be repeated for credit with a different topic. PREREQUISITE: Permission of Department Chairman. *Graded on Pass/Fail basis only.*

MS 4312 Advanced Materials (4-0).
The course is structured to provide a vehicle for the study of materials pertinent to a specific area of environment utilization or design. Example categories are marine materials, nuclear materials, elevated-temperature materials, aircraft alloys, materials for energy conversion. Topics discussed may include material failures, materials selection, testing, and new concepts in materials engineering. Course scope is decided by mutual agreement of students and Instructor. PREREQUISITES: MS 2201, MS 3202, or equivalent.

MS 4811 Mechanical Behavior of Engineering Materials (4-0).
The response of structural materials to mechanical stress is discussed with emphasis on plastic deformation in metals. Topics include mechanisms of high-temperature deformation, fatigue, and fracture. New concepts allowing development of materials to circumvent these failure mechanisms are treated. PREREQUISITES: MS 3202 or permission of Instructor.

DEPARTMENT OF METEOROLOGY

Air/Ocean Sciences Ph.D. student receiving real-time meteorological data analyses and forecasts in the Department of Meteorology weather analysis and briefing laboratory

Robert Joseph Renard, Professor of Meteorology; Chairman (1952)*; M.S., Univ. of Chicago, 1952; Ph.D., Florida State Univ., 1970.

David Adamec, Adjunct Research Professor of Meteorology (1978); B.S., Florida State Univ., 1976; M.S., 1978; Ph.D., Naval Postgraduate School, 1985.

James Stephen Boyle, Adjunct Professor of Meteorology (1981); B.S., Iona College, 1968; M.S., State Univ. of New York at Albany, 1975; Ph.D., 1980.

Johnny Chung-Leung Chan, Adjunct Research Professor of Meteorology (1985); B.S., Univ. of Hong Kong, 1974; M.Phil., (Physics) 1976; Ph.D., Colorado State Univ., 1982.

Chih-Pei Chang, Professor of Meteorology (1972); B.S., National Taiwan Univ., 1966; Ph.D., Univ. of Washington, 1972.

Lang Chiu Chou, Adjunct Research Instructor (1977); B.S., Tunghai Univ., 1968; M.S., Univ. of Washington, 1977.

Kenneth La Vern Davidson, Professor of Meteorology (1970); B.S., Univ. of Minnesota, 1962; M.S., Univ. of Michigan, 1966; Ph.D., 1970.

Philip Andrew Durkee, Assistant Professor of Meteorology (1984); B.S., Univ. of Minnesota, 1978; M.S., Colorado State Univ., 1980; Ph.D., 1984.

Russell Leonard Elsberry, Professor of Meteorology (1968); B.S., Colorado State Univ., 1963; Ph.D., 1968.

Robert Lawrence Gall, NAVAIR G.J. Haltiner Research Chair Professor of Meteorology (1984); B.S., Pennsylvania State Univ., 1967; M.S., Univ. of Wisconsin, 1969; Ph.D., 1972.

Gerald LeRoy Geernaert, Adjunct Research Professor of Meteorology (1985); B.S., Univ. of California at Davis, 1977; Ph.D., Univ. of Washington, 1983.

Robert Lee Haney, Professor of Meteorology (1970); A.B., George Washington Univ., 1964; Ph.D., Univ. of California at Los Angeles, 1971.

Chi-Sann Egon Liou, Adjunct Research Professor of Meteorology (1983); B.S., National Central Univ., Taiwan, 1973; M.S., 1977; Ph.D., Univ. of California at Los Angeles, 1982.

Torben Mikkelsen, Adjunct Research Professor of Meteorology (1985); B.S. Copenhagen Technikum, 1975; M.S., Tech. Univ. of Denmark, 1978; Ph.D., 1983.

Melinda Shuntai Peng, Adjunct Research Professor of Meteorology (1984); B.S., National Central Univ., Taiwan, 1974; M.S., Atmospheric Sciences, St. Univ. of N.Y. at Albany, 1978; M.S., Computer Sciences, 1980; Ph.D., 1982.

Rudolph William Proisendorfer, Professor of Meteorology (1986); B.S., Massachusetts Institute of Technology, 1952; Ph.D., Univ. of California at Los Angeles, 1956.

Mary Alice Rennick, Adjunct Research Professor of Meteorology (1981); B.S., Knox College, 1970; M.S., Univ. of Illinois, 1972; Ph.D., 1975.

William Jason Shaw, Assistant Professor of Meteorology (1983); B.S., Furman Univ., 1975; Ph.D., Univ. of Washington, 1982.

Warren Theodore Spaeth, Jr., Commander, U.S. Navy; Instructor in Meteorology (1983); B.S., U.S. Naval Academy, 1968; M.S., Naval Postgraduate School, 1975.

Dennis Walter Thomson, NAVAIR G.J. Haltiner Research Chair Professor of Meteorology (1986); B.S., Univ. of Wisconsin, 1963; M.S., 1964; Ph.D., 1968.

Willem van der Bijl, Associate Professor of Meteorology (1961); B.S., Free Univ. of Amsterdam, 1941; M.S., 1943; Ph.D., State Univ. Utrecht, 1952.

Carlyle Hilton Wash, Associate Professor of Meteorology (1980); B.S., Univ. of Wisconsin, 1969; M.S., 1975; Ph.D., 1978.

Forrest Roger Williams, Adjunct Professor Meteorology (1983); B.S., U.S. Naval Academy, 1956; M.S., Naval Postgraduate School, 1962; M.S., Massachusetts Institute of Technology, 1972.

Roger Terry Williams, Professor of Meteorology (1968); A.B., Univ. of California at Los Angeles, 1959; M.A., 1961; Ph.D., 1963.

Emeritus Faculty

William Dwight Duthie, Distinguished Professor Emeritus (1945); B.A., Univ. of Washington, 1935; M.S., 1937; Ph.D., Princeton Univ., 1940.

George Joseph Haltiner, Distinguished Professor Emeritus (1946); B.S., College of St. Thomas, 1940; Ph.M., Univ of Wisconsin, 1942; Ph.D., 1948.

Frank Lionel Martin, Professor Emeritus (1947); B.A., Univ. of British Columbia, 1936; M.A., 1938; Ph.D., Univ. of Chicago, 1941.

**The year of joining the Postgraduate School faculty/staff is indicated in parentheses.*

DEPARTMENT REQUIREMENTS FOR DEGREES IN METEOROLOGY OR METEOROLOGY AND OCEANOGRAPHY

MASTER OF SCIENCE IN METEOROLOGY

1. Entrance to a program leading to a Master of Science degree in Meteorology requires a baccalaureate degree with completion of mathematics through differential and integral calculus and a minimum of one year of college physics.

2. The degree of Master of Science in Meteorology requires completion of:

a. Mathematics courses in vector analysis, partial differential equations, and application of numerical methods and computers to the solution of differential equations.

b. A basic course in applied probability and statistics.

c. The basic sequence of graduate courses in the fields of dynamical, physical and synoptic meteorology, which must include eighteen quarter hours in the 4000 series.

d. An acceptable thesis.

MASTER OF SCIENCE IN METEOROLOGY AND OCEANOGRAPHY

1. Direct entrance to a program leading to the degree Master of Science in Meteorology and Oceanography requires a baccalaureate degree, preferably in physical sciences, mathematics or engineering. This normally permits the validation of a number of required undergraduate courses such as physics, chemistry, differential equations, linear algebra, vector analysis and various courses in meteorology and/or oceanography, which are prerequisites to the graduate program. These prerequisites may be taken at the Naval Postgraduate School; however, in that event the program may be lengthened by one or more quarters.

2. The degree of Master of Science in Meteorology and Oceanography requires:

a. Completion of forty-eight quarter hours in meteorology and oceanography, to include at least twenty hours in the 4000 series, with a minimum of one 4000-level course in other than directed study.

b. The basic sequence of graduate courses in the fields of dynamical, physical and synoptic meteorology/oceanography must be included in the forty-eight hours.

c. Completion of an acceptable thesis on a topic approved by either department.

DOCTOR OF PHILOSOPHY

The Ph.D. Program is offered in the Department of Meteorology in the following areas of study: numerical weather prediction, geophysical fluid dynamics, analysis of atmospheric systems and tropical meteorology.

The requirements for the degree are grouped into three categories: course work, research in conjunction with an approved dissertation, and examination in both the major and a minor field. The minor field is usually in oceanography, mathematics or physics.

The required examinations are described in this catalog in the section Requirements for the Doctor's Degree. The Department of Meteorology may also require a preliminary examination to show evidence of acceptability as a doctoral student.

Prospective students should consult with the Chairman of the Department of Meteorology for further guidance regarding doctoral programs.

METEOROLOGICAL LABORATORIES

In addition to the standard synoptic laboratories, NPS meteorological facilities include most instruments in present-day use for observing the atmosphere as well as equipment for copying weather analyses and forecasts emanating from the National Weather Service, including the DIFAX facsimile network system and the COMEDS link with the Automated Weather Network. Similar information is received from Fleet Numerical Oceanography Center via daily messenger, the Naval Environmental Display System and the Navy/NOAA Oceanographic Data Distribution System. Weather satellite data are received on a UNIFAX recorder via GOESTAP and displayed in animated form. Rawinsonde equipment, an acoustic sounder and micrometeorologically instrumented masts on the NPS research vessel are utilized by faculty and students in the meteorology and oceanography programs. Interactive computer processing of satellite and conventional data is conducted using the COMTAL image analysis system and the VAX 11/750 minicomputer in the Computer Science Department Laboratory. A new Joint Meteorology/Oceanography Laboratory for Interactive Digital Image and Graphical Analysis begins operation in 1986 to provide real-time acquisition and analysis of remotely-sensed data in support of the synoptic and physical meteorology programs.

DEPARTMENTAL COURSE OFFERINGS

MR 0110-11-12-13 Applications Seminars (1-0).
Presentation of DOD related research activities, applications to weapons and warfare systems, utilization of oceanography and meteorology in specific billets, presentations by faculty, staff, selected students and visiting authorities. MR 0110 is for orientation; MR 0111 is for intermediate students; MR 0112/0113 is for thesis orientation/topic selection. PREREQUISITE: Enrollment in an Air-Ocean Science curriculum.

MR 0810 Thesis Research (0-0).
Every student conducting thesis research will enroll in this course.

MR 0999 Seminar in Meteorology (2-0).
Students present results of thesis or other approved research investigation. PREREQUISITE: Concurrent preparation of thesis or other acceptable research paper.

Upper Division Courses

MR 2020 Computer Computations in Air-Ocean Sciences (1-2).
Introduction to FORTRAN and the NPS main frame computer as applied to elementary problems in oceanography and meteorology. PREREQUISITES: Calculus and college physics.

MR 2200 Introduction to Meteorology (4-0).
An introductory course that treats the composition and structure of the atmosphere, thermodynamic processes, forces and related small- and large-scale motions, air masses, fronts, severe storms, solar and terrestrial radiation, general circulations and weather forecasting. PREREQUISITE: Department approval. *(May be taken through Continuing Education as minicourses MR 2201-02.)*

MR 2210 Introduction to Meteorology/Laboratory (4-2).
Same course as MR 2200 plus laboratory periods illustrating lecture material, including weather map analysis over oceanic areas using satellite imagery. PREREQUISITE: Department approval.

MR 2220 Marine Meteorology (4-1).
An introductory course covering forces and related small- and large-scale atmospheric motions and their interaction with the ocean, severe rotating storms, fronts, general circulation and radiation, atmospheric stability, observation techniques, synoptic charts over marine regions, basics of remote sensing and satellite imagery interpretation, forecasting, climates over the ocean and sea ice and icebergs. Laboratory exercises illustrate lecture material. PREREQUISITE: Department approval.

MR 2300 Observations, Instruments and Climatology (3-2).
Surface and upper-air observations, including rawinsondes. Instruments used in synoptic observations. Climate classifications, changes and controls; basic statistical quantities used in climatology; applications to world climates. PREREQUISITE: Introductory Meteorology course concurrently.

MR 2413 Meteorology for Antisubmarine Warfare (3-1).
Atmospheric factors affecting the fluxes of momentum, heat and moisture across the air-sea interface; local and synoptic scale atmospheric features relevant to electromagnetic and electro-optical wave propagation; hands-on experience with existing environmental effects assessment models. PREREQUISITES: Differential and integral calculus concurrently.

MR 2416 Meteorology for Electronic Warfare (2-0).
A survey of environmental factors affecting the propagation and attenuation of electromagnetic waves. Synoptic and climatological conditions associated with anomalous refraction are studied. Layers associated with high aerosol concentration and optical turbulence are identified. Hands on experience with existing environmental effects assessment models. PREREQUISITES: Calculus, Computer Programming, Electromagnetic Theory concurrently.

MR 2419 Atmospheric Factors In C^3 (2-0).
A survey of atmospheric properties and processes affecting propagation of electromagnetic (EM) and electro-optical (EO) wave. Tropospheric phenomena associated with standard and anomalous EM wave propagation at wavelengths greater than 10 meters. Ionospheric phenomena associated with larger wavelength (Hf) propagation. PRE—REQUISITE: Enrollment in C^3 curriculum.

MR 2520 Survey of Air-Ocean Remote Sensing (3-0).
Overview of systems for remote sensing of the atmosphere and oceans from space, and operational applications. PREREQUISITES: Undergraduate Physics and Calculus, or consent of Instructor.

Upper Division or Graduate Courses

MR 3140 Probability and Statistics for Air-Ocean Science (3-2).
Basic probability and statistics, in the air-ocean science context. Techniques of statistical data analysis. Structure of a probability model, density distribution function, expectation and variance. Binomial, Poisson and Gaussian distributions. Conditional probability and independence. Joint distributions, covariance and central limit theorem. Transformations of random variables. Histograms and empirical distributions and associated characteristics such as moments and percentiles. Standard tests of hypotheses and confidence intervals for both one and two parameter situations. Regression analysis as related to least squares estimation. PREREQUISITE: Calculus.

MR 3150 Analysis of Air/Ocean Time Series (3-2).
Analysis methods for atmospheric and oceanic time series. Correlation, spectrum, and empirical orthogonal function analyses. Statistical objective analysis. Optimal design of air-ocean data networks. PREREQUISITES: MA 2121, and a probability and statistics course.

MR 3212 Polar Meteorology/Oceanography (3-1).
Operational aspects of arctic and antarctic meteorology. Polar oceanography. Sea-ice; its seasonal distribution, melting and freezing processes, physical and mechanical properties, drift and predictions. Aspects of geology and geophysics. PREREQUISITES: OC 3240, MR 3222 or consent of Instructor.

MR 3220 Meteorological Analysis (4-0).
Techniques of evaluation, interpretation and analysis of pressure, wind, temperature, and moisture data, including weather satellite observations, with emphasis on the low and middle troposphere. Synoptic models of extratropical vortices, waves and frontal systems, with emphasis on three dimensional space structure and time continuity. Introduction to analysis in the high troposphere and low stratosphere. PREREQUISITES: MR 3420, MR/OC 3321.

MR 3222 Meteorological Analysis/ Laboratory (4-3).
Same as MR 3220 plus laboratory sessions on the concepts considered in the lectures, with emphasis on the analysis of the low and middle troposphere, streamline and isotach analysis techniques, satellite interpretation, and vertical cross section analyses. PREREQUISITE: MR 3420, MR/OC 3321.

MR 3230 Tropospheric and Stratospheric Meteorology (4-0).
An analytic and synoptic interpretation of tropospheric and stratospheric systems with emphasis on the middle and high altitude aspects of extratropical cyclones, jet streams and fronts, and related dynamical properties. PREREQUISITES: MR 3220 or MR 3222, MR 4322 concurrently.

MR 3235 Tropospheric and Stratospheric Meteorology Laboratory (0-7).
Practice in synoptic-scale analysis of parameters considered in MR 3230 with emphasis on objectivity, interrelationships and application to diagnostic problems. PREREQUISITES: MR 3222, MR 3230 concurrently.

MR 3250 Tropical Meteorology (3-0).
Structure and mechanisms of synoptic-scale wave disturbances, cloud clusters, upper-tropospheric systems, the intertropical convergence zone, tropical cyclones and monsoon circulations; with emphasis on tropical cyclones, tropical scale analysis and energetics. PREREQUISITES: MR 4322; MR 3230, MR 3235 may be concurrent.

MR 3252 Tropical Meteorology/Laboratory (3-4).
Same as MR 3250 plus laboratory sessions on analysis of tropical systems emphasizing streamline and isotach analysis and incorporating aircraft and satellite observations. Exercises stress tropical cyclone structure, tropical general circulation and the monsoon regimes. Satellite imagery are used as an analysis tool and also in forecasting tropical cyclone intensity. A track forecasting exercise provides an exposure to the use of various dynamic, climatological and statistical forecast models. PREREQUISITES: MR 4322; MR 3230, MR 3235 may be concurrent.

MR 3260 Operational Atmospheric Prediction (3-0).
Subjective and objective methods of atmospheric prognosis and techniques for forecasting operationally-important weather elements from surface to 100 mb. Interpretation, use and systematic errors of computer-generated products. Weather satellite briefs and applications of forecasting principles to current situations. PREREQUISITES: MR 3230, MR/OC 4323 or consent of Instructor.

MR 3262 Operational Atmospheric Prediction/Laboratory (3-3).
Same as MR 3260 plus laboratory sessions on the application of lecture material. Also, practice in weather briefing, including diagnosis and forecasting of current weather situations using weather satellite observations and National Meteorological Center and Fleet Numerical Oceanography Center products. PREREQUISITES: MR 3230, MR/OC 4323 or consent of Instructor.

MR 3321 Air-Ocean Fluid Dynamics (4-0).
The hydrodynamical equations for a rotating stratified fluid. Forces, kinematics, boundary conditions, scale analysis. Simple balanced flows; baroclinicity, thermal wind; vorticity and divergence: rotational and divergent part of the wind; circulation theorem. Vorticity and potential vorticity. PREREQUISITE: MA 2047 may be concurrent, or equivalent.

MR 3420 Atmospheric Thermodynamics (3-0).
The physical variables; properties of gases, water and moist air; equations of state and the laws of thermodynamics applied to the atmosphere and oceans; entropy, adiabatic processes and potential temperatures; meteorological thermodynamic diagrams; geopotential and hydrostatic equilibrium, vertical motion in the atmosphere, stability criteria and condensation levels. PREREQUISITE: MA 1116 or equivalent. *(May be taken through Continuing Education as mini-courses MR 3418-19.)*

MR 3421 Cloud Physics (3-0).
Basic principles of cloud and precipitation physics and application to weather modification. Selected topics in atmospheric pollution. PREREQUISITE: MR 3420.

MR 3445 Oceanic and Atmospheric Observational Systems (2-2).
Principles of measurement: sensors, data acquisition systems, calibration, etc. Methods of measurement for thermodynamic and dynamic variables in the ocean and atmosphere, including acoustics and optics. PREREQUISITES: OC 3230 and MR 3420.

MR 3520 Remote Sensing of the Atmosphere and Ocean (4-0).
Principles of radiative transfer and satellite sensors and systems; visual, infrared and microwave radiometry and radar systems; application of satellite remotely-sensed data in the measurement of atmospheric and oceanic variability. PREREQUISITES: Undergraduate physics and differential/integral calculus; ordinary differential equations or consent of Instructor.

MR 3522 Remote Sensing of the Atmosphere and Ocean/Laboratory (4-2).
Same as MR 3520 plus laboratory sessions on the concepts considered in the lecture series. PREREQUISITES: Undergraduate physics and differential/integral calculus; ordinary differential equations or consent of Instructor.

MR 3540 Physical Processes in the Lower and Upper Atmosphere (3-0).
Applications of radiation theory to atmospheric energy budgets, general circulation and anthropogenic climate changes. Radiational imbalance at the surface leading to heat fluxes and temperature changes in atmosphere and earth. Upper atmosphere phenomena (ozonosphere and ionosphere). Precipitation and cloud physics. The role of pollutants. Atmospheric electricity; optical phenomena. PREREQUISITES: MR 3420, MR 3520 or MR 3522.

Graduate Courses

MR 4241 Mesoscale Meteorology (3-0).
Descriptive and physical understanding of subsynoptic scale weather systems and their relation to the synoptic-scale environment. Applications to short-range and local-area forecasting utilizing satellite and numerical-model products relevant to mesoscale weather phenomena. PREREQUISITES: MR 3230; MR/OC 4323, or MR 4322 with consent of Instructor.

MR 4242 Advanced Tropical Meteorology (3-0).
Theories and observations of equatorial waves and oscillations; energy sources and instabilities; boundary layer and cumulus convection parameterization; monsoon circulations and their interactions with other scales; Tropical cyclone models and forecasting; selected topics in diagnostic and theoretical studies of tropical flows. PREREQUISITE: MR 3250 and consent of Instructor.

MR 4250 General Circulation of the Atmosphere and Oceans (3-0).
Selected topics on the general circulation of the atmosphere (e.g., heat, momentum and moisture fluxes; energetics) and ocean (e.g., linear and nonlinear theories of the wind-driven ocean circulation, nonlinear thermocline theories, mesoscale eddies, mixed-layer theories); coupled ocean-atmosphere general circulation models. PREREQUISITE: Consent of Instructor.

MR 4322 Dynamic Meteorology (4-0).
Pressure coordinates, scale analysis, perturbation method; solutions of equations of motion for sound, gravity and synoptic waves; baroclinic and barotropic instability; energetics; geostrophic adjustment. PREREQUISITE: MR 3420, MR/ OC 3321, MA 2047, MA 2121 or equivalent.

MR 4323 Numerical Air and Ocean Modeling (4-2).
Numerical models of atmospheric and oceanographic phenomena. Finite difference techniques for solving hyperbolic, parabolic and elliptic equations, linear and nonlinear computational instability. Spectral and finite element models. Filtered and primitive equation prediction models. Sigma coor-dinates. Objective analysis and initialization. Moisture and heating as time permits. PREREQUISITES: MR 4322, MA 3132; MA 3232 desirable.

MR 4324 Advanced Numerical Weather Prediction (3-0).
Initialization, boundary conditions; sensible, latent and radiative heat transfer; simulation of sub-grid scale processes such as convection and friction; spectral methods and finite element models; general circulation models, PREREQUISITE: MR/OC 4323 or consent of Instructor.

MR 4331 Advanced Geophysical Fluid Dyamics I (3-0).
Advanced topics in the dynamics of the atmosphere and the oceans including scale analysis; geostrophic adjustment; dispersion, and barotropic and baroclinic instabilities. PREREQUISITE: Consent of Instructor.

MR 4332 Advanced Geophysical Fluid Dynamics II (3-0).
Energetics of unstable disturbances; frontogenesis; boundary layer analysis with application to the Ekman layer and to the frictional and the nonlinear ocean boundary currents; finite amplitude baroclinic waves. PREREQUISITE: Consent of Instructor.

MR 4413 Air/Sea Interaction (4-0).
Fundamental concepts in turbulence. The atmospheric planetary boundary layer, including surface layer, and bulk formulae for estimating air-sea fluxes. The oceanic planetary boundary layer including the dynamics of the well-mixed surface layer. Recent papers on large-scale air-sea interaction. PREREQUISITE: OC 3240 or MR 4322 (may be concurrent), or consent of instructor.

MR 4414 Advanced Air/Sea Interaction (3-0).
Advanced topics in the dynamics of the atmospheric and oceanic planetary boundary layers. PREREQUISITE: MR/OC 4413 or consent of Instructor.

MR 4415 Atmospheric Turbulence (3-0).
Approaches for defining the structure of the turbulent atmospheric boundary layer. Review of statistical descriptions of atmospheric turbulence; averaging, moments, joint moments, spectral representation. Equations for a turbulent regime in a stratified, shear flow. Scaling parameters and similarity theories for surface layer profiles, spectra; Kolmogorov hypotheses, Monin-Obukhov stability length. Measurement of atmospheric turbulence. Examination of observed spectra and scales of atmospheric turbulence. PREREQUISITES: MR/OC 3150 or consent of Instructor.

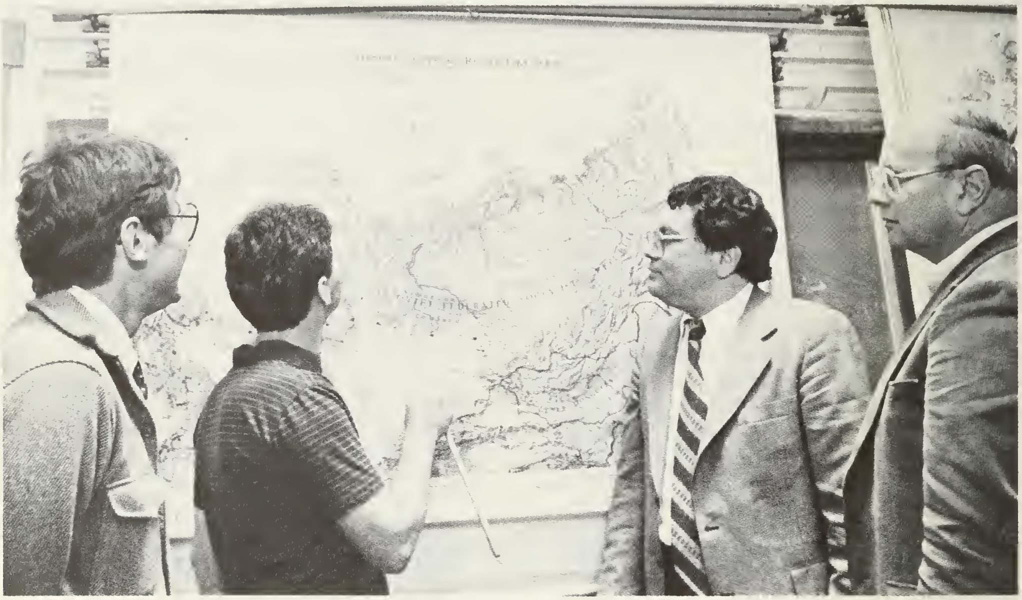
MR 4416 Atmospheric Factors in Electromagnetic and Optical Propagation (4-0).
Principles of microwave and optical wave propagation in the atmosphere. Effects of atmosphere on propagation; refraction, scattering, attenuation, ducting, etc. PREREQUISITE: MR/OC 4413 concurrently.

MR 4520 Topics in Satellite Remote Sensing (3-0).
Selected topics in the advanced application of satellite remote sensing to the measurement of atmospheric and oceanic variables. PREREQUISITE: MR/OC 3522.

MR 4800 Advanced Topics in Meteorology (1-0 to 4-0).
Advanced topics in various aspects of meteorology. Topics not covered in regularly offered courses. The course may be repeated for credit as topics change. PREREQUISITE: Consent of Department Chairman and Instructor.

MR 4900 Special Topics in Meteorology (1-0 to 4-0).
Directed study of selected areas of meteorology to meet the needs of the individual student. PREREQUISITE: Consent of Department Chairman and Instructor. *Graded on Pass/Fail basis only.*

DEPARTMENT OF NATIONAL SECURITY AFFAIRS



Examination of Strategic Aspects of Area Studies

Sherman Wesley Blandin, Jr., Professor of National Security Affairs; Chairman (1968)*; B.S., U.S. Naval Academy, 1944; B.S., Georgia Institute of Technology, 1952; M.S., 1953; M.B.A., Univ. of Santa Clara, 1973; Ph.D., 1977.

John William Amos, II, Associate Professor of Political Science (1970); B.A., Occidental College, 1957; M.A., Univ. of California at Berkeley, 1962; Ph.D., 1972; J.D., Monterey College of Law, 1979.

Robert Barry Bathurst, Adjunct Professor of National Security Affairs (1981); B.A., Northwestern Univ., 1949; M.A., 1956; Ph.D., Brown Univ., 1977.

David P. Burke, Adjunct Professor of National Security Affairs (1980); A.B., University of California at Berkeley, 1956; M.A., San Francisco State College, 1963; M.P.A., Harvard, 1969; Ph.D., 1975.

Claude Albert Buss, Adjunct Professor of Political Science and History (1976); B.A., Washington Missionary College, 1922; M.A., Susquehanna Univ., 1924; Ph.D., Univ. of Pennsylvania, 1927.

Michael William Clough, Assistant Professor of Political Science (1979); B.A., Univ. of California at Santa Barbara, 1974; M.A., Univ. of California at Berkeley, 1976, Ph.D., 1983.

Donald Charles Daniel, Associate Professor of Political Science (1975); A.B., Holy Cross College, 1966; Ph.D., Georgetown Univ., 1971.

Richard L. Forney, Lieutenant Colonel, USAF; Instructor (1984); B.S., Colorado State Univ., 1968; M.B.A., Florida State Univ., 1972.

Patrick J. Garrity, Adjunct Teaching Professor of National Security Affairs (1985); B.A., The College of Idaho, 1977; M.A., Claremont Graduate School, 1979; Ph.D., 1982.

Katherine Lydigsen Herbig, Adjunct Research Professor of National Security Affairs (1980); B.A., Knox College, 1968; M.A., Claremont Graduate School, 1972; Ph.D., 1977.

Boyd Francis Huff, Professor Emeritus of Government and History (1958); B.A., Univ. of Washington, 1938; M.A., Brown Univ., 1941; Ph.D., Univ. of California at Berkeley, 1955.

Harlan Wardell Jencks, Adjunct Professor of National Security Affairs (1982); B.A., Univ. of Washington, 1963; M.A., 1971; Ph.D., 1978.

Stephen Jurika, Jr., Adjunct Professor of National Security Affairs (1975); B.S., U.S. Naval Academy, 1933; M.A., George Washington University, 1957; Ph.D., Stanford University, 1962.

Edward John Laurance, Associate Professor of Political Science (1972); B.S., U.S. Military Academy, 1960; M.A., Temple Univ., 1970; Ph.D., Univ. of Pennsylvania, 1973.

Robert Edward Looney, Associate Professor of National Security Affairs (1979); B.S., Univ. of California at Davis, 1963; Ph.D., 1969.

Ralph Harry Magnus, Associate Professor of National Security Affairs (1976); A.B., Univ. of California at Berkeley, 1958; M.A., 1966; Ph.D., 1971.

Edward Allan Olsen, Associate Professor of National Security Affairs (1980); B.A., Univ. of California at Los Angeles, 1968; M.A., Univ. of California at Berkeley, 1970; Ph.D., The American Univ., 1974.

Patrick Johnston Parker, Professor of Systems Analysis (1974); M.B.A., Univ. of Chicago, 1955.

Kamil Taha Said, Adjunct Professor of National Security Affairs (1975); B.A., Colorado State College, 1937; M.A., San Jose State College, 1967.

Joseph Sternberg, Professor of National Security Affairs (1985); B.S., California Institute of Technology, 1942; M.S., 1943; Ph.D., Johns Hopkins University, 1955.

Russel Henry Stolfi, Professor of History (1966); B.S., Stanford Univ., 1954; M.A., 1964; Ph.D., 1966.

Frank Michael Teti, Associate Professor of Political Science (1966); B.A., Los Angeles State College, 1960; M.A., 1962; Diploma, Institute of World Affairs, 1961; M.P.A., Syracuse Univ., 1972; Ph.D., 1966.

Jiri Valenta, Associate Professor of National Security Affairs (1976); Ing. Pol. Ek., Prague School of Economics, 1968; Ph.D., Johns Hopkins Univ., 1975.

David Scott Yost, Associate Professor of International Relations (1979); B.A., Univ. of Southern California, 1970; M.A., 1970; M.S., 1973; Ph.D., 1976.

**The year of joining the Postgraduate School faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR THE DEGREE MASTER OF SCIENCE IN NATIONAL SECURITY AFFAIRS

The degree Master of Science in National Security Affairs will be awarded upon the completion of an interdisciplinary program carried out in accordance with the following degree requirements:

a. A minimum of 45 quarter hours of graduate level work of which at least 12 hours must represent courses at the 4000 level. Graduate courses in at least three different academic disciplines must be included and, in two disciplines a course at the 4000 level must be included.

b. In addition to the 45 hours of course credit, an acceptable thesis must be completed.

c. The program must be approved by the Chairman of the Department of National Security Affairs.

DEPARTMENTAL COURSE OFFERINGS

National Security Affairs Department

NS 0010, 0020, 0030, and 0040 Seminar for National Security Affairs Students (0-2).
Guest Lecturers, Thesis and Research Presentations. NS 0010 is for Intelligence, NS 0020 for Functional Specialty, NS 0030 for Area Specialty and NS 0040 for all NSA Curricula.

NS 0810 Thesis Research (0-0).
Students conducting thesis research will enroll in this course.

NS 0811 Preparation for Comprehensive Examination (0-0).
Students preparing for comprehensive examinations will enroll in this course.

Lower Division Course

NS 1500 American Life and Institutions (3-0).
American political institutions and the political, social, economic, and cultural aspects of American Life. OPEN ONLY TO ALLIED OFFICERS. *Graded on Pass/Fail basis only.*

NS 2154 Intelligence and the Military (4-0).
An overview of the intelligence structure and a survey of the intelligence process focusing on the application of intelligence to the military mission. The organization and functions of the various elements of the intelligence community are presented. Primary emphasis is placed on the use of intelligence by military decision makers. Included are overviews of systems supporting the collection, production and dissemination of intelligence. The course is intended for the non-intelligence specialist and is available to any student wishing to learn about the intelligence community and its ability to provide support to the military.

Upper Division or Graduate Courses

NS 3010 Comparative Political Analysis and Research Methods (4-0).
An analytical and comparative study of the form and functioning of the major types of contemporary governments, with emphasis on the policymaking process and research methods. *Graded on Pass/Fail basis only.*

NS 3020 Analysis of International Relations (4-0).
A theoretical systematic analysis of international relations and a study of factors, organizational strategies, and techniques of international politics, to include a segment on cross-national security assistance and arms transfers.

NS 3021 The Role of the Superpowers in the Third World (4-0).
An analysis of evolving bi-polar or multipolar influences on the developing nations focusing on the role of the United States, Soviet Union, Great Britain, Japan, and emerging nation politico-military and economic systems in the Third World. PREREQUISITE: NS 3040.

NS 3030 American National Security Policy (4-0).
An institutional and functional analysis of the national and international factors which shape U.S. defense policy. Attention in the course is focused on two major areas; 1) the decision-making process, including the legislative-executive budgetary process, as well as the influence of bureaucratic politics and interest group participation upon defense decisions; 2) the problems of strategic choice, including security assistance, threat analysis, net assessment, deterrence theory, and limited war.

NS 3040 The Politics of Global Economic Relations (4-0).
An integrated analysis on the economic and political factors that together determine national and international economic arrangements. The student first addresses the general principles of public finance as a prerequisite for the analysis of budgets and policy priorities in specific countries and areas. The remainder of the course is concerned with the changing world economic order including issues such as trade, aid, cross-national security assistance, multi-national corporations, technology and strategic resources.

NS 3150 Intelligence Data Analysis and Research Methods (4-2).
A survey of methods and techniques for synthesis, analysis, interpretation, and reporting of data. Topics include sampling methods, content analysis, data handling and processing, scaling techniques, and parametric and non-parametric tests, with emphasis on application to intelligence. PREREQUISITES: OS 3101, MA 2311 or equivalent. TOP SECRET Clearannce with eligibility for SPECIAL INTELLIGENCE information.

NS 3151 Intelligence Systems and Products (4-0).
This course is intended for students in the command and control program. It provides an introduction to intelligence systems and products which support command decision making, an overview of Soviet command and control concepts and practices required for an appreciation of the significance of intelligence reporting, an insight into intelligence procedures to provide perspective for operational security planning, and material on Soviet intelligence organizations and capabilities. PREREQUISITES: TOP SECRET clearance with eligibility for SI/SAO, U.S. Citizenship. SPECIAL INTELLIGENCE information.

NS 3152 Naval Warfare and the Threat Environment (4-0).
This course supports NPS warfare curricula. It concentrates on the threat posed by Soviet naval warfare forces to successful accomplishment of the U.S. Navy's missions. Issues include: U.S. missions in conflict situations; U.S. intelligence and analysis of the Soviet threat; the politico-military and strategic contexts underlying the use of Soviet naval and other forces for maritime warfare; current status and trends in Soviet naval warfare capabilities; continuities and changes in the missions and operations of Soviet naval and related forces; trends in the superpower naval warfare balance. Secret Clearance required.

NS 3153 Military Applications of Space (4-0).
Examination of the military functions which utilize space systems and the capabilities of current systems, impact of space operations on military strategy, doctrine and tactics. National space policy and national organizations involved in space policy, DoD and service relationships. Tasking and use of space systems and ground support elements and techniques to reduce vulnerability. Impact of current R&D programs. PREREQUISITES: TOP SECRET clearance with eligibility for SPECIAL INTELLIGENCE information.

NS 3230 Strategic Planning and U.S. National Security Policy (4-0).
The focus of this course will be on long term Strategic Planning and will include such topics as: Strategic Goal Analysis, national and transnational power assessment, analysis of the decision making and administrative processes at the national level, indigenous constraints on the policy process, forecasting and future research techniques and the application of the concepts of strategic planning to the national defense effort. PREREQUISITE: NS 3030.

NS 3250 Defense Resources Allocation (4-1).
A presentation of the concepts, principles and methods of defense resources allocation as they pertain to planning, programming, budgeting and related activities. Emphasis is placed on the analytical aspects of decision making drawn from the disciplines of management theory, economics and quantitative analysis. The laboratory sessions include problems and case studies in which the concepts and methods are applied to illustrative situations. PREREQUISITE: Consent of Instructor. *Graded on Pass/Fail basis only.*

NS 3263 Strategic Planning for Southwest Asia (4-0).
Examination of the political and military factors necessary for consideration in the development of a successful Western strategy for the defense of Southwest Asia.

NS 3279 Directed Studies in National Security Affairs (Credit open).
Format and content vary. Normally involves extensive assigned readings, individual discussions with the instructor, papers and/or examination.

NS 3280 Nuclear Weapons and Foreign Policy (4-0).
An interdisciplinary course which covers both the technology and political influences of nuclear weapon systems. The course emphasizes the interaction of nuclear weapon systems with the foreign policies of the major powers and the political blocs from 1945-present.

NS 3300 Foundations of Middle Eastern Politics: Peoples, Societies, Cultures and Religions (4-0).
An intensive course in Middle Eastern history from the viewpoint of geographical and military factors which have shaped the course of events in the area. The geographic (including oceanographic) environment within which military campaigns have been conducted, which continues to present military problems, is examined. Indigenous and foreign techniques and tactics for dealing with this environment, as well as the historical development of Middle Eastern military organizations are studied.

NS 3301 20th Century Middle Eastern Military and Political History (4-0).
A follow-on course to NS 3300 which continues the study of Middle Eastern history from the 19th through the 20th Century. Emphasis is placed on the political and military factors which shaped strategic events. Special attention is given to the genesis and development of nationalist movements in the area and their impact on Middle Eastern politics. PREREQUISITE: NS 3300.

NS 3310 Problems of Government and Security in the Middle East (4-0).
An introductory course in Middle Eastern society and politics designed to provide the maximum background area knowledge to be utilized in follow-on courses in Middle Eastern politics.

NS 3320 International Relations and Security Problems in the Middle East (4-0).
The course focuses on selected problems affecting American security interests in the Middle East: Strategic waterways, including the Suez Canal, the Turkish Straits, and the Indian Ocean; the politics and problems of access to the area's oil resources; the development of U.S. and Soviet policies toward area. The foregoing problems will be set in the context of regional international politics.

NS 3330 United States Interests and Policies in the Middle East (4-0).
This course offers an analysis of the historical backgrounds and the current status of United States cultural, economic, political and strategic interests in the Middle East. It traces the changing definitions of these interests over time and the alternative policies which have been adopted in order to secure them. The relationship of these policies to broader aspects of United States foreign policy is discussed along with the impact of the policy-making process upon the substance of policies.

NS 3341 Seminar on Middle East Oil (4-0).
An examination of the oil resources of the Middle East for their impact upon the internal, regional, and international policies of region-states. The role of international oil companies, consuming states, and organizations of exporting countries is studied. Difference in oil resources and revenues are examined and related to different developmental and international policies. The past and future use of oil as a political weapon is discussed and evaluated. The use of revenues from oil is examined for its impace on levels of development and the regional military balance.

NS 3350 The Middle East: The Military Dimension (4-0).
An examination of the political, sociological, cultural and strategic roles of the military in Middle Eastern history and politics. Among the topics considered are: traditional military patterns, military recruitment, organization, doctrine, and learning experiences.

NS 3360 North Africa: Problems of Government and Security in the Maghreb (4-0).
This course is design to extend the student's knowledge of selected North African and Red Sea littoral countries, and to provide some insight into the security problems presented by their domestic politics. In addition, some coverage of central African countries will be included.

NS 3361 Problems of Government and Security in Israel (4-0).
Israeli cultural social, and political patterns: Hebraic traditions, Zionism and the creation of Israel, institutional and sociological frameworks for Israeli politics, elite recruitment, perceptions and strategic orientations, security issues in Israeli domestic and foreign policy. PREREQUISITES: NS 3310 or NS 3301, or their equivalent.

NS 3362 Problems of Government and Security in the Northern Tier: Turkey, Iran, Afghanistan, Pakistan (4-0).
An examination of internal and external political, economic, and social forces in the major non-Arab Middle Eastern states as reflected in their internal development and

international policies. Cooperation and conflict in the behavior of these nations toward each other will be explored in the context of their recent efforts at regional cooperation and regional organization (the Sa'dabad Pact, Cento, and RCD). Examination of their relationships to the major outside powers interested in the area, i.e., the U.S. and the Soviet Union. Their relationships both as individual states and as a sub-region with the Arab states of the Middle East. PREREQUISITES: NS 3310 and NS 3320.

NS 3379 Directed Studies: Middle East (Credit open).
Format and content vary by student and professor agreement. Normally involves extensive assigned readings, individual discussions with the instructor, papers and/or examinations.

NS 3400 Domestic Context of Soviet National Security Policy (4-0).
An examination of the role of domestic factors shaping Soviet national security policy: geography, military and economic capabilities, historical influences and traditions, nationalities and demography, ideological influences, and political and economic systems. Emphasis is on the impact of the domestic environment on current Soviet national security policymaking with implications for the United States.

NS 3410 Soviet National Security (4-0).
A follow-up course to NS 3400. Primary focus is on Soviet images of national security and long trends in the development of national security policy since World War II through the leaderships of Stalin, Khrushchev and Brezhnev, and thereafter. Soviet efforts to safeguard their national security objectives are demonstrated through a comparative analysis of crisis management situations at their periphery (intervention and coercion of Hungary, Czechoslovakia, Afghanistan and Poland) and in strategic areas of the Third World (Cuban missile crisis and conflict and war in the Middle East, Angola, Ethiopia and Central America). Implications are drawn for U.S. security. PREREQUISITES: NS 3400 or consent of instructor.

NS 3450 Soviet Military Strategy (4-0).
Examination of internal and external factors conditioning Soviet military doctrine and strategy and their development through the Stalin, Khruschev and Brezhnev eras and beyond. Emphasis is on contemporary Soviet strategic concepts and strategy: surprise and deception, war-fighting capabilities, external role of the Soviet armed forces, strategy for nuclear war, Warsaw Treaty Organization strategy, and Soviet naval strategy in the Third World.

NS 3452 Soviet Naval and Maritime Strategy (4-0).
Examination of the roles played by the Soviet Navy, Merchant Marine, Fishing Fleet, and Oceanological establishment in securing the objectives of the Soviet Government. Topics include: geographic factors affecting Soviet ocean strategies; non-naval strategy trends; international and domestic factors affecting post-1953 naval strategy; development of Soviet naval warfare capabilities; doctrinal and functional analysis of post-1953 trends in naval strategy; command structure; personnel training; law of the sea positions; U.S.-Soviet naval interaction. PREREQUISITE: TOP SECRET clearance with eligibility for SPECIAL INTELLIGENCE information.

NS 3479 DIRECTED STUDIES: SOVIET UNION (Credit Open).
Format and content vary. Normally involves extensive assigned readings, individual discussions with the professor, papers and/or examinations.

NS 3500 Perspectives on American Civilization (4-0).
This course, especially designed for the foreign area studies (attache) program, is an interdisciplinary study of American culture, involving the political, economic, social, philosophical and literary development of the Nation from 1789 to the present.

NS 3501 History and Culture of Latin America (4-0).
Identifies those aspects of the heritage most relevant to understanding contemporary conditions in Latin America, from pre-Columbian Indian traditions and Iberian colonial patterns through the independence movements of the early 19th century and the global economic relationships which reoriented the region toward Northwestern Europe and the United States.

NS 3510 Problems of Government and Security in Latin America (4-0).
Considers the nature of political legitimacy in Latin America. Comparative studies indicate the relative role of revolutionary movements, constitutionalism, and economic output as sources of social cohesion. Major political factors such as technocrats, organized labor, the church, political parties and the military are studied in reference to how they respond to demands for radical change. Critical analysis of government capacity to meet challenges indicates the degree to which countries in the region face a significant likelihood of instability stemming from internal and/or external sources. Specific countries are given attention based on the future assignments of the students.

NS 3520 International Relations and Security Problems of Latin America (4-0).
Surveys the attempts by countries from various parts of the world — including the Soviet bloc — to penetrate Latin America. The influences of cultural and economic ties, military sales and political subversion have created links between Latin America and Europe with an undercurrent of African relations. The activities coming from outside the region are evaluated in comparison with the efforts of Latin American states to gain diplomatic influence in global organizations and to establish economic links to serve development goals.

NS 3530 United States Interests in Latin America (4-0).
A critical look at Latin America, and at the case made by analysts who argue that U.S. policy has neglected the region as compared with that of the critics of U.S. influence. Traditional views of neighbors sharing a common heritage and geo-political interest are evaluated. The importance of cultural, economic, and military ties are considered in the context of American global economic and security concerns.

NS 3540 Political Economy of Latin American Development Strategies (4-0).
Examination of the forces affecting the interface of economic and political interests in development strategies, especially since the end of World War II. The objectives sought, obstacles encountered, and means utilized are evaluated. External and internal factors are compared in reference both to measurable contributions and to the perceptions of Latin American leaders.

NS 3550 The Role of the Military in Latin America (4-0).
A broad view of the variety of functions served by the military in Latin American societies. Many Latin American military organizations have had training and advisory links with several countries from outside the region. A number of countries have also developed comprehensive doctrines of both military and other activities as part of research and training at advanced staff schools. Some have overseas combat experience, while many have been involved in internal security operations. These factors are considered by this course along with interservice and civil-military relations.

The 357X sequence consists of a series of a series of directed studies of particular subareas of Latin America. Each individual course description corresponds to that given below for NS 3570.

NS 3570 Directed Studies: Latin America (credit open).
Format and content vary. Normally involves extensive assigned readings, individual discussions with the instructor, papers and/or examination.

NS 3571 Directed Studies: Canada (credit open).

NS 3572 Directed Studies: Brazil (credit open)

NS 3573 Directed Studies: Southern Cone Countries (credit open).

NS 3574 Directed Studies: Andean Region (credit open).

NS 3575 Directed Studies: Cuba (credit open).

NS 3576 Directed Studies: Mexico (credit open).

NS 3577 Directed Studies: Central America and the Caribbean (credit open).

NS 3579 Directed Studies: Western Hemisphere (credit open).

NS 3600 Geography, History and Cultures of Asia (4-0).
An introduction to Asia. This basic course addresses the peoples of Asia and their cultures, civilizations, social organization, economic, political and military development before the coming of Europeans. This course is a prerequisite for the advanced courses on Asia.

NS 3620 International Conflicts of Asia to World War II (4-0).
An analysis of the impact of the West on the peoples of Asia, showing the historical roots of many contemporary conflicts of policy.

NS 3630 Foundations of U.S. Policy in Asia (4-0).
A study of 19th and early 20th century U.S. interests and policy toward Asia. Focuses on the emergence of Asian affairs as an issue for American policy-makers and the public from the U.S. revolution through World War II. Emphasis is placed on tracing Asian-American political, economic, strategic, and cultural interaction as it influenced U.S. policy and the policies of key Asian states.

NS 3631 U.S. Security Interests and Policies in Asia since World War II (4-0).
A study of the national interests of the United Stated in East Asia, South Asia and adjacent oceans from World War II to the present. The development of hostilities in Korea and Vietnam and their aftermath. Evaluation of relations with the new Japan, the PRC and Taiwan, and the independent nations of Asia, produced by the breakup of traditional empires.

NS 3661 Problems of Government and Security in China (4-0).
The rise of the Chinese Communist Party and the establishment of the Communist state; its domestic achievements and problems; the special problem of Taiwan; changing foreign policies and the current role of the Peoples Republic of China in world affairs.

NS 3662 Problems of Government and Security of Contemporary Japan (4-0).
The place of Japan in the modern world; and examination of Japan's political dynamics, economic evolution, social transformation, the National Self Defense Forces and alternatives for providing for national security.

NS 3663 Problems of Government and Security of Contemporary Korea (4-0).
Division of the Korean nation into two states; the aftermath of the Korean war; domestic political, economic and social problems of North Korea and South Korea; the prospects for reunification; the military balance and the changing strategic environment; the relations of Pyongyang and Seoul, with their key allies.

NS 3664 Problems of Government and Security in Southeast Asia (4-0).
Consideration given to such internal problems as the growth of nationalism, the role of overseas Chinese, and numerous other social changes, economic modernization, insurgencies, conflicting ideologies and the various types of government. External problems include the role of each nation state and regional groups in international affairs and the interests and policies of outside powers in dealing with the area.

NS 3665 Problems of Government and Security in Australia, New Zealand and Melanesia (4-0).
The politics, economics, and foreign relations of Australia, New Zealand, and Melanesia (4-0).
The politics, economics, and foreign relations of Australia, New Zealand, and Melanesian states. The emergence of new states, and the importance of the area's relations with the United States, the Commonwealth, Western Europe and ASEAN, ANZUS, the U.S.

NS 3666 Problems of Government and Security in South Asia and the Indian Ocean Area (4-0).
Internal problems and foreign relations among the states in the region of South Asia and the Indian Ocean; the strategic interests of the major powers; the importance of the Indian Ocean to the United States, the Soviet Union and their respective allies.

The NS 367X sequence consists of a series of directed studies of particular subareas of the Far East, Southeast Asia and Pacific. Each individual course description corresponds to that given below for NS 3671.

NS 3671 Directed Studies: China (credit open).
Format and content vary. Normally involves extensive assigned readings, individual discussions with the instructor, papers and/or examinations.

NS 3672 Directed Studies: Japan (credit open).

NS 3673 Directed Studies: Korea (credit open).

NS 3674 Directed Studies: Southeast Asia (credit open).

NS 3675 Directed Studies: Australia and New Zealand (credit open).

NS 3676 Directed Studies: South Asia (credit open).

NS 3679 Directed Studies: General Asia (credit open).

NS 3700 History of Europe and Russia, Pre 1917 (4-0).
Review and analysis of the political and military history of Europe, including Russia, from the Congress of Vienna to the outbreak of World War I.

NS 3701 History of Europe and the USSR, Post 1917 (4-0).
This course continues the narrative and analysis begun in NS 3700, bringing the student from World War I and the Bolshevik Revolution to the conclusion of World War II.

NS 3710 Problems of Government and Security in Contemporary Western Europe (4-0).
Review and analysis of the history of Western Europe since 1945, including an introduction to the institutions of the European Economic Community and the North Atlantic Treaty Organization. Emphasis on the political systems and security policies of Britain, France, Italy, and the Federal Republic of Germany.

NS 3720 International Relations and Security Problems of the North Atlantic Alliance (4-0).
The origins and evolution of NATO in relation to the perceived threat from the East and the postwar recovery of Europe. Problems of strategy, force posture, alliance cohesion, nuclear policy and the differing interests of NATO states. Current issues facing the alliance and their relation to U.S. foreign and defense policy.

NS 3760 Problems of Government and Security in the Mediterranean Region (4-0).
This course provides an introduction to security problems in the Mediterranean region, with special emphasis on U.S. and Soviet policy as well as on the governments of the northern littoral of the Mediterranean.

NS 3761 Problems of Government and Security in the Scandinavian-Baltic Region (4-0).
This course analyzes the political, economic, social, and security problems faced by the Scandinavian-Baltic countries. The role they play on the northern flank of NATO will be examined as well as their position vis-a-vis the growing threat of Soviet military and naval power in the Baltic and Norwegian seas.

NS 3762 Problems of Government and Security in the Federal Republic of Germany (4-0).
The origins of the Federal Republic of Germany; political system, economy, and decision-making; central foreign policy problems, including relations with the U.S., the USSR, and the German Democratic Republic; the Bundeswehr and current security issues.

NS 3763 Problems of Government and Security in France (4-0).
The Fourth and Fifth Republics in the context of French political history; political system, economy, and decision-making; central foreign policy problems, including relations with the U.S., the USSR, the Federal Republic of Germany, and Africa; the French armed forces and current security issues.

The NS 377X sequence consists of a series of directed studies of particular subareas of Europe. Each individual course description corresponds to that given below for NS 3770.

NS 3770 Directed Studies: Mediterranean (credit open).
Format and content vary. Normally involves extensive assigned readings, individual discussions with the instructor, papers and/or examinations.

NS 3771 Directed Studies: Scandinavia-Baltic (credit open).

NS 3772 Directed Studies: Federal Republic of Germany (credit open).

NS 3773 Directed Studies: France (credit open).

NS 3774 Directed Studies: United Kingdom (credit open).

NS 3775 Directed Studies: Italy (credit open).

NS 3776 Directed Studies: Iberia (credit open).

NS 3777 Directed Studies: Eastern Europe (credit open).

NS 3779 Directed Studies: General West Europe (credit open).

NS 3800 History and Culture of Sub-Saharan Africa (4-0).
An examination of the major historical trends that have shaped African societies. Emphasis will be placed on the interaction between geography, culture, economics and politics. The pre-colonial, and colonial periods in African history will be discussed in detail. This course is intended as a general introduction for the student just beginning the study of Africa.

NS 3810 Problems of Government and Security in Sub-Saharan Africa (4-0).
Emergence of independent African states from a shared colonial heritage, and their common problems in developing viable modern nation-states. Patterns of international cooperation and conflict among African states, including discussions of African socialism, negritude, pan-Africanism, neutralism, and the continuing problem of South Africa's future. Rival policies of outside powers, including the U.S., the Soviet Union, China and the former colonial powers.

NS 3811 Conflict and Change in Africa (4-0).
An examination of the underlying cultural, economic and political sources of conflict and change in Africa. Topics to be covered will include: irredentism, civil wars and boundary disputes, ethnic cleavages and political competition, modernization and political instability. These topics will be analyzed by examining a series of case studies to include: the Congo crisis, the Nigerian civil war, the Eritrean conflict, the Shaba crisis and the Sudanese civil war.

NS 3830 American Interests in Africa (4-0).
This course examines the evolution of American relations with Africa from 1960 to the present. It focuses on the ways in which changing geopolitical and economic conditions have altered official perceptions of American interests in Africa — including the Mahgreb. U.S. involvement in conflicts in the Belgium Congo, Nigeria, Angola, Rhodesia and the Horn of Africa will be studied.

NS 3840 African Political Development Strategies (4-0).
An examination of the political modernization strategies adopted by post-independence governments in Africa. Issues to be discussed will include: the role of political parties in Africa, economic development, the role of the military in Africa, socialism in Africa, and the like. Special emphasis will be placed on Africa's early post-independence problems and their effect on current African strategies.

NS 3879 Directed Studies: African Area Studies (Credit open).
Format and content vary. Normally involves extensive assigned readings, individual discussions with the instructor, papers and/or examinations.

NS 3900 International Organizations and Negotiations (4-0).
The first part of the course traces the evolution of international organizations from the Concert of Europe, through the League of Nations, United Nations, European Economic Community and NATO, to current forms of organization such as multinational corporations and transnational terrorist groups. The emphasis is on the policymaking process in these organizations and their interaction with nation-States and the international system. The second part of the course is an analysis of international negotiations, with emphasis on applying theories of negotiation to such issues as conflict resolution and arms control.

NS 3902 Modern Revolution and Political Terrorism (4-0).
Study of the general historical framework of modern revolution to include systematical analysis of the development of modern revolutionary situations. Examination of the more important revolutions of modern times, including study of the historical events, testing of the methods of systematic analysis, with emphasis on revolutionary tactics, e.g. political terrorism.

NS 3960 International Law (4-0).
An introduction to the principles of International Law including sovereignty, territory, recognition, the Law of the Sea, and the laws of war. Special emphasis is on the Law of the Sea, its development, practice, and prospects.

NS 3961 The Law of War (4-0).
The course presents and analyzes the law of war as it is to be observed and enforced by the Armed Forces of the United States. Special attention is paid to the 1949 Geneva Conventions, the Navy's *Law of Naval Warfare* and the Army's *Law of Land Warfare.*

NS 3962 Ocean, Maritime and Tort Law for the Hydrographic Community (4-0).
This course is designed to provide a detailed introduction to the personal and institutional liabilities and immunities of the hydrographic community. As such, it will consist of a general introduction to governmental tort law, including the applicable sections of the Federal Tort Claims Act and pertinent cases; relevant areas of Admiralty law and international law, both public and private, as it applies to the rights and duties pertaining to access to, and use of both international and sovereign waters. In addition, special emphasis will be given to the historical and legal developments of the law of the sea; and to present day trends in international conventions leading up to the proposed Law of the Sea Treaty.

Graduate Courses

NS 4010 Seminar in Comparative Regional Security (4-0).
A seminar designed for geographical security area students to address global security issues on a comparative basis. PREREQUISITES: NS 3310, 3410, 3630, 3710, or 3810.

NS 4020 Seminar in Comparative Foreign Policy (4-0).
The objective of this Seminar is to develop the student's ability to analyze and predict the international behavior of states. Emphasis will be placed on comparing the impact of different factors, such as international structure, domestic politics, bureaucratic institutions, economic resources and ideology, on the foreign policies of different countries. Students will be expected to write a seminar paper using the theoretical material covered in the course to compare the foreign policies of two or more countries. PREREQUISITE: NS 3020 or permission of the instructor.

NS 4040 Strategic Resources and U.S. National Security Policy (4-0).
Analysis of the problems of access to global resources and their utilization: agricultural production; access to critical raw materials; problems and politics of oil; national and international implications of various strategies of self-sufficiency and interdependency. Emphasis is placed on the security problems arising from the geographic distribution of international resources. PREREQUISITES: NS 3030, NS 3020.

NS 4041 Development and the World Economy (4-0).
A comparative analysis of problems of politico-economic growth and development, focusing on selected developing nations. Alternate systems are compared with respect to development goals, theories of economic organization, institutions and development processes. Emphasis is placed on forecasts of likely changes in economic and political conditions and their effect on the political-military situation in each country. PREREQUISITE: NS 3021 or consent of the Instructor.

NS 4079 Advanced Directed Studies in National Security Affairs (Credit open).
Format and content vary. Normally involves extensive individual research under direction of the instructor and submission of a substantial paper of graduate seminar quality and scope.

NS 4151 Comparative Command, Control, Communications and Ocean Surveillance (3-0).
An examination of the command and organizational structures, control philosophies, communications systems and ocean surveillance systems of the Soviet and U.S. Navies. The course begins with the Soviet approach, which is used as a basis of comparison with the U.S. approach. Possible exploitable features of the command and control structure are considered. The course emphasizes readings in the appropriate literature, research and seminar discussions. PREREQUISITE: TOP SECRET clearance with access to SPECIAL INTELLIGENCE information; NS 3452, SE 2003, OS 3002 or equivalent. May also be taught as SE 4064.

NS 4152 Problems of Intelligence and Threat Analysis (4-0).
This advanced course focuses on problems in analyzing the intentions and capabilities of a military competitor, especially the Soviet Union. This course is specifically intended to draw on the knowledge and experience of practioners and analysts in the Naval intelligence community. Students will be given the opportunity to undertake analyses where they can apply methods and concepts acquired in earlier courses. PREREQUISITE: NS 3150 or NS 3154 or permission of the Instructor. *Graded on a Pass/Fail basis only.* TOP SECRET clearance with eligibility for SPECIAL INTELLIGENCE information.

NS 4179 Advanced Directed Studies: Intelligence (Credit open).
Format and content vary. Normally involves extensive individual research under direction of the instructor and submission of a substantial paper of graduate seminar quality and scope.

NS 4230 Seminar in Strategic Planning (4-0).
Advanced study in the concepts and methods of long-range defense planning and analysis, particularly with respect to iterative aggregation and synthesis in the Military Departments, the Joint Chiefs of Staff, the office of the Secretary of Defense and the National Security Council. Students are expected to identify and address some evolving strategic issues which have significant long-term implications for the security of the U.S. PREREQUISITE: NS 3230 or permission of Instructor. *Graded on a Pass/Fail basis only.*

NS 4231 Science, Technology & Public Policy (4-0).
Advanced study and research in the role of science and technology in the formulation and conduct of U.S. national policy, to include interactions among scientific communities, government and the military services. A research focus will be determined for each course. PREREQUISITE: Consent of the Instructor. *Graded on a Pass/Fail basis only.*

NS 4250 Problems of Security Assistance and Arms Transfers (4-0).
An analysis of the patterns, purposes and effects of cross-national security assistance, including arms sales and the transfer of technology. Special topics include: factors dominating the arms transfer policies of the major powers; the role of the military in recipient nations; the role of the military attache; the design, execution and evaluation of security assistance programs. PREREQUISITES: NS 3030 or NS 3020.

NS 4251 American National Security Objectives and Net Assessment (4-0).
Comparative analysis of trends in U.S. and Soviet security policies, military forces, manpower, and capabilities. Special attention is paid to familiarizing students with original source material and major elements in current controversial national security issues. Topics covered include nuclear capabilities and doctrine, BMD and air defense, civil defense, combined arms employment, NATO Warsaw Pact military balance, naval forces, and trends in the U.S. and Soviet ecomies, especially as they affect the allocation of resources to defense. PREREQUISITE: TOP SECRET Clearance with eligibility for SPECIAL INTELLIGENCE information.

NS 4261 Survey of Strategic Studies (4-0).
An extensive survey of the classical and contemporary literature on strategic thinking; national objectives and strategic alternatives; deterrence, counterforce, arms control, counter insurgency, compellence; components and rules of the international strategic system; arms competitions, nuclear proliferation, terrorism. Student projects on current strategic problems are a major component of the course. PREREQUISITE: NS 3020.

NS 4262 Seminar in Strategic Deception (4-0).
This course explores the utility of strategic deception in advancing military/political objectives from a variety of social scientific perspectives; both historical case studies and contemporary issues will be considered. PREREQUISITE: NS 3230 or consent of Instructor.

NS 4279 Advanced Directed Studies: Strategic Planning (Credit Open).
Format and content vary. Normally involves extensive individual research under direction of the instructor and submission of a substantial paper of graduate seminar quality and scope.

NS 4300 Seminar in Middle Eastern Civilizations (4-0).
Description and analysis of the four major cultural traditions of the Middle East: Arabic, Persian, Judaic, and Turkish. Students read translations of selected classical and contemporary writings from each of these traditions, and secondary materials concerning social and cultural institutions. PREREQUISITES: NS 3310 or NS 3300, or consent of Instructor.

NS 4310 Seminar in Security Problems of the Middle East (4-0).
Advanced Middle Eastern politics and the security problems they present to U.S. decision-makers. The central theme of the course is U.S. interests in the Middle East, how these interests are threatened, and what policy alternatives have been proposed to secure them. PREREQUISITE: NS 3310 or NS 3320.

NS 4340 Seminar in Political Economy of the Middle East (4-0).
A survey of the major issues of development economics in selected Middle Eastern countries. The basic types of political-ideological systems in the region are examined. A detailed analysis of the economies in each system is made with the ultimate objective of assessing future political-economic developments in the area. PREREQUISITES: NS 3040 and NS 3310.

NS 4379 Advanced Directed Studies: Middle East (Credit Open).
Format and content vary. Normally involves extensive individual research under direction of the instructor and submission of a substantial paper of graduate seminar quality and scope.

NS 4410 Seminar in Soviet Security Problems (4-0).
An advanced seminar for all students specializing in Soviet and East European affairs designed to provide an introduction to primary methodological approaches for studying Soviet national security (macroanalytical, microanalytical, unitary actor, bureaucratic politics) and methodological techniques (content analysis, Kremlinology, mathematical-statistical methods, and others). Course is also designed to provide students with an opportunity to engage in advanced study and research of specialized topics relating to Soviet security problems in cooperation with the major Soviet study centers and leading Soviet scholars in the United States and abroad. PREREQUISITE: NS 3400, 3410 and 3450.

NS 4420 Security Problems and International Relations of the Warsaw Treaty Organization (WTO) (4-0).
An advanced study of structures and policy-making in the WTO countries and other Communist countries not having WTO membership, above all, China, Yugoslavia, Cuba and Vietnam. Focus on the origin and evolution of the WTO alliance, problems of joint strategy, alliance cohesion and reliability, differing interests of various WTO members, conflict management within the alliance and WTO member relations with other important Communist, NATO and Third World countries. Current issues such as the Soviet-Cuban joint intervention in Africa and involvement in the Caribbean basin, the Soviet alliance with Vietnam in Southeast Asia, Soviet-East German military-security operations in the Third World, and the dynamics of Sino-Soviet relations are viewed with an eye to their implications for the United States. PREREQUISITES: NS 3400, 3410, and 3450, or consent of instructor.

NS 4451 Advanced Topics in Soviet Naval Affairs (4-0).
Advanced study and research in Soviet naval and maritime affairs. Topics include: decision-making processes, scenarios, warfare capabilities and support systems, missions; and U.S.-Soviet naval interactions. PREREQUISITE: TOP SECRET Clearance with eligibility for SPECIAL INTELLIGENCE information.

NS 4460 Seminar in Eastern European Affairs (4-0).
Advanced study and research in government, politics, international relations and national security affairs in the comunist-ruled states of Europe other than the Soviet Union.

NS 4479 Advanced Directed Studies: Soviet Union (Credit Open)
Format and content vary. Normally involves extensive individual research under direction of the instructor and submission of a substantial paper of graduate seminar quality and scope.

NS 4500 Seminar in the National Interest (4-0).
An advanced study of the underlying assumptions and objectives of American security and foreign policy. The core of the course is an in-depth analysis of the American national interest in the international context. Students are required to write a major seminar paper on American national interests in a specific country or region.

NS 4560 Seminar in International Security Problems of Latin America (4-0).
Reviews the history of Latin America as part of an inter-American system, and the cases of joint foreign policy action on economic, political, and military fronts. Case studies draw attention to the role of the United States in the region, both within the formal regional institutions and in bilateral relations including military advisory activities. The relations are put in the context of the attitudes of Latin American leaders toward hemispheric solidarity.

The 457X sequence consists of a series of directed studies of particular subareas of Latin America. Each individual course description corresponds to that given below for NS 4570.

NS 4570 Advanced Directed Studies: Latin America (credit open).
Format and content vary. Normally involves extensive individual research under direction of the instructor, and submission of a substantial paper of graduate seminar quality and scope.

NS 4571 Advanced Directed Studies: Canada (credit open).

NS 4572 Advanced Directed Studies: Brazil (credit open).

NS 4573 Advanced Directed Studies: Southern Cone Countries (credit open).

NS 4574 Advanced Directed Studies: Andean Region (credit open).

NS 4575 Advanced Directed Studies: Cuba (credit open).

NS 4576 Advanced Directed Studies: Mexico (credit open).

NS 4577 Advanced Directed Studies: Central America (credit open) and the Caribbean.

NS 4579 Advanced Directed Studies: Western Hemisphere (credit open).

NS 4660 Asia and Soviet Union (4-0).
An advanced study of the interests and policies of the Soviet Union in Asia and the adjacent oceans, with special reference to the impact of Soviet expansiveness on the policies of the United States, China, Japan and other Asian States. This course is open both to Soviet and Asian area specialists.

The NS 467X sequence consists of a series of directed studies of particular subareas of the Far East, Southeast Asia and Pacific. Each individual course description corresponds to that given below for NS 4671.

NS 4671 Advanced Directed Studies: China (credit open).
Format and content vary. Normally involves extensive individual research under direction of the instructor, and submission of a substantial paper of graduate seminar quality and scope.

NS 4672 Advanced Directed Studies: Japan (credit open).

NS 4673 Advanced Directed Studies: Korea (credit open).

NS 4674 Advanced Directed Studies: Southeast Asia (credit open).

NS 4675 Advanced Directed Studies: Australia and New Zealand (credit open).

NS 4676 Advanced Directed Studies: South Asia (Credit open).

NS 4679 Advanced Directed Studies in General Asia (Credit open).
Normally involves extensive individual research under direction of instructor and submission of substantial paper of graduate seminar quality and scope. Designed for advanced study in one of the following areas: Japan, Korea, China, South or Southeast Asia.

NS 4690 International Security Problems of Asia and the Adjacent Oceans (4-0).
Advanced study of Asian security issues with special emphasis on the balance of forces, regional and external alliances, prospects for conflict, and Asian concepts of security and strategy. PREREQUISITE: Consent of Instructor.

NS 4710 Seminar in Political and Security Problems of Europe (4-0).
A research seminar on political and security issues in contemporary Europe. Students

conduct and present original research on a selected issue, or related issues, in specific European countries or subregions. The issue around which the seminar is structured varies from term to term. It is chosen to meet the research interests of each group of students enrolled in the course.

NS 4720 Seminar in Soviet-European Relations (4-0).
A seminar intended to deepen the student's knowledge of current issues in Soviet and European affairs.

The 477X sequence consists of a series of directed studies of particular subareas of Europe. Each individual course description corresponds to that given below for NS 4770.

NS 4770 Advanced Direced Studies: Mediterranean (credit open).
Format and content vary. Normally involves extensive individual research under direction of the instructor, and submission of a substantial paper of graduate seminar quality and scope.

NS 4771 Advanced Directed Studies: Scandinavia-Baltic (credit open).

NS 4772 Advanced Directed Studies: Federal Republic of Germany (credit open).

NS 4773 Advanced Directed Studies: France (credit open).

NS 4774 Advanced Directed Studies: United Kingdom (credit open).

NS 4775 Advanced Directed Studies: Italy (credit open).

NS 4776 Advanced Directed Studies: Iberia (credit open).

NS 4777 Advanced Directed Studies: Eastern Europe (credit open).

NS 4779 Advanced Directed Studies: General Western Europe (credit open).

NS 4810 Current Problems in Africa (4-0).
This course will examine the major problems and crises that have confronted African leaders since 1970. Particular attention will be paid to conflicts in Southern Africa. The OAU's role in conflict management will also be discussed.

NS 4830 American Policy Towards Africa (4-0).
The central theme of the course is U.S. interests in Africa, how these interests are threatened, and what policy alternatives have been proposed to secure them. Advanced African politics and the security problems they present to U.S. decision-makers. PREREQUISITES: NS 3340, NS 3840 or NS 3820.

NS 4879 Advanced Directed Studies: African Area Studies (Credit open).
Format and content vary. Normally involves extensive individual research under direction of the instructor and submission of a substantial paper of graduate seminar quality and scope.

NS 4900 Seminar in International Negotiations (4-0).
Advanced study and research of the international negotiating process, designed to provide students with an opportunity to analyze specific topics related to negotiating national security.

NS 4901 Seminar in Ocean Policy (4-0).
An advanced survey of the oceanographic, military, political and legal problems of the oceans. Among the topics dealt with are: comparative regional military oceanography, politics and strategy of fleet deployment, and international legal constraints on naval operations.

NS 4902 Seminar on Modern Revolution and Terrorism (4-0).
A research seminar on modern revolution and terrorism. Students will be introduced to the general sources of information and accomplish the research necessary to complete a seminar paper in a related area of their choice. PREREQUISITE: NS 3902.

NS 4950 Seminar on Arms Control and National Security (4-0).
An analysis of international negotiation processes as related to the control of armaments, including a review of the history of modern arms control efforts, examination of the domestic political context of arms limitation, the implications of international law relevant to treaty negotiation, ratification and enforcement, the intellectual contributions of scientists to the development of arms control theory, and a review of selected substantive issues with respect to security concerns, verification capabilities and compliance measures. PREREQUISITES: NS 3450 and 3900 or consent of the Instructor and SECRET Clearance.

DEPARTMENT OF OCEANOGRAPHY

Mapping Charting and Geodesy students check out the operation of the wild T-3 optical theodolite used for precise positioning in hydrographic surveying

Christopher Northrup Kennard Mooers, Professor of Oceanography; Chairman (1979)*; B.S., U.S. Naval Academy, 1957; M.S., Univ. of Connecticut, 1964; Ph.D., Oregon State Univ., 1969.

Robert Hathaway Bourke, Associate Professor of Oceanography (1971); B.S., Naval Academy, 1960; M.S., Oregon State Univ., 1969; Ph.D., 1972.

Douglas Earl Colton, Adjunct Research Professor of Oceanography (1983); B.A., State University New York at Geneseo, 1974; M.S., Florida Institute of Technology, 1978; Ph.D., 1982.

Calvin Ray Dunlap III, Adjunct Research Professor of Oceanography (1983); B.S., Naval Academy, 1962; M.S., Naval Postgraduate School, 1968; M.A., Stanford University, 1972.

Roland William Garwood, Jr., Associate Professor of Oceanography (1976); B.S., Bucknell Univ., 1967; Ph.D., Univ. of Washington, 1976.

Eugene Clinton Haderlie, Distinguished Professor of Oceanography (1965); A.B., Univ. of California at Berkeley, 1943; M.A., 1948; Ph.D., 1950.

Edward A. Kelley, Adjunct Research Professor of Oceanography (1984); B.S., Ohio State University (1950); M.S. Florida State University (1961); Ph.D., Florida State University (1984).

Rolf Geor Lueck, Adjunct Research Professor of Oceanography (1982); B.S., Univ. of British Columbia, 1973; Ph.D., 1979.

James Lowell Mueller, Adjunct Research Professor of Oceanography (1980); B.S., U.S. Coast Guard Academy, 1962; Ph.D., Oregon State Univ., 1974.

Henry Joseph Niebauer, Visiting Professor, CNR Chair in Arctic Marine Science (1984); B.S., Univ. of Wisconsin (1967); Ph.D., Univ. of Wisconsin (1976).

Thomas Ray Osborn, Professor of Oceanography (1981); A.B., Univ. of Illinois, 1963; M.Sc., 1964; Ph.D., Univ. of California at San Diego, 1969.

Michele Marie Rienecker, Adjunct Research Professor of Oceanography (1982); B.Sc., Univ. of Queensland, 1974; Ph.D., Univ. of Adelaide, 1980.

Narendra Kumar Saxena, Adjunct Research Professor, CNOC Chair in MC&G (1984); Diplom-Ingeniuer, Technical University (Hanover), 1966; Doktor Der Technischen Wissenschaften, Technical University (Graz), 1972.

Glen Richard Schaefer, Commander, NOAA Corps; Instructor in Hydrography (1983); B.S., University of Wisconsin, 1965; M.S., 1974.

Timothy Peter Stanton, Adjunct Research Professor of Oceanography (1978); B.S., University of Auckland, 1974; M.S., 1977.

Edward Bennett Thornton, Professor of Oceanography (1969); Williamette Univ., 1962; B.S., Stanford Univ., 1962; M.S., Oregon State Univ., 1965; M.E.C.E., Univ. of Florida, 1966; Ph.D., 1970.

Stevens Parrington Tucker, Assistant Professor of Oceanography (1968); B.S., Stanford Univ., 1955; M.S., Oregon State Univ., 1963; Ph.D., 1972.

Chung-Shang Wu, Adjunct Research Professor of Oceanography (1983); B.A., Chenkum University, Taiwan, 1974; M.S., University of Southern California, 1979; Ph.D., Cornell University, 1983.

Hidekatsu Yamazaki, Adjunct Research Professor of Oceanography (1984); B.E., Tokai University, Japan (1977); M-Tech, Tokai University (1979); Ph.D., Texas A&M University (1984).

Emeritus Faculty

Glenn Harold Jung, Professor Emeritus (1958); B.S., Massachusetts Institute of Technology, 1949; M.S. 1952; Ph.D., Texas A&M Univ., 1955.

Dale Frederick Leipper, Professor Emeritus (1968); B.S., Wittenberg Univ., 1937; M.A., Ohio State Univ., 1939; Ph.D., Scripps Institution of Oceanography, 1950; Hon. D.Sc., Wittenberg Univ., 1968.

Robert George Paquette, Professor Emeritus (1971); B.S., Univ. of Washington, 1936, Ph.D., 1941.

Warren Charles Thompson, Professor Emeritus (1953); B.A., Univ. of California at Los Angeles, 1943; M.S., Scripps Institution of Oceanography, 1948; Ph.D., Texas A&M Univ., 1953.

Eugene Dewees Traganza, Associate Professor Emeritus (1970); B.A., Indiana Univ., 1955; M.S., Texas A&M Univ., 1959; Ph.D., Univ. of Miami, 1966.

Jacob Bertram Wickham, Associate Professor Emeritus (1951); B.S., Univ. of California at Berkeley, 1947; M.S., Scripps Institution of Oceanography, 1949.

The year of joining the Postgraduate School Faculty is indicated in parentheses.

Oceanography is the study of the physical, chemical, geological, and biological systems of the sea. At NPS physical oceanography is emphasized, including its relationships with meteorology and physics, especially in topics of air-sea interaction, underwater acoustics and optics, ice physics, and small scale processes. In all these matters, ocean prediction is the central thrust; that is, the analysis and forecast of the ocean's present and future states, and their influence on naval operations and systems. Hydrographic science (a discipline of mapping, charting and geodesy or MC&G) is concerned with the measurement, description, and mapping of the sea floor with special reference to navigation and marine operations. The Department of Oceanography is the center for these studies at NPS. Officers are prepared to make best use of knowledge and understanding of the ocean in the course of their duties, and to carry out and evaluate research in oceanographic and hydrographic sciences, both basic and applied.

The curricula are sponsored by the Oceanographer of the Navy and Commander, Naval Oceanography Command. Research is supported through grants and contracts with various government agencies including the Office of Naval Research.

DEPARTMENT REQUIREMENTS FOR DEGREES IN OCEANOGRPHY

MASTER OF SCIENCE IN OCEANOGRAPHY

1. Entrance to a program leading to the degree Master of Science in Oceanography requires a baccalaureate degree. Minimal requirements include mathematics through differential and integral calculus, one year of college physics, and one year of college chemistry. Previous experience at sea is considered advantageous.

2. The degree of Master of Science in Oceanography requires:
   a. Completion of thirty-five quarter hours of graduate courses of which fifteen hours must be in the 4000 oceanography series. The entire sequence of courses selected must be approved by the Department of Oceanography.
   b. Completion of an acceptable thesis on a topic approved by the Department of Oceanography.

MASTER OF SCIENCE IN HYDROGRAPHIC SCIENCES

1. Entrance to a program leading to the degree Master of Science in Hydrographic Sciences requires a baccalaureate degree. Minimal requirements include mathematics through differential and integral calculus, one year of college physics, and one year of college chemistry. Previous experience at sea is considered advantageous.

2. The degree of Master of Science in Hydrographic Sciences requires:
   a. Completion of forty quarter hours of graduate courses in the hydrographic sciences series of which twelve hours must be at the 4000 level. The entire sequence of courses must be approved by the Department of Oceanography.
   b. Completion of an acceptable thesis on a topic approved by the Department of Oceanography.

MASTER OF SCIENCE IN METEOROLOGY AND OCEANOGRAPHY

1. Direct entrance to a program leading to the degree Master of Science in Meteorology and Oceanography requires a baccalaureate degree preferably in one of the physical sciences, mathematics, or engineering. This normally permits the validation of a number of required undergraduate courses such as physics, chemistry, differential equations, linear algebra, vector analysis and various courses in meteorology and/or

oceanography, which are prerequisites to the graduate program. These prerequisites may be taken at the Naval Postgraduate School; however, in that event the program may be lengthened by one or more quarters.

2. The degree of Master of Science in Meteorology and Oceanography requires:

  a. Completion of forty-eight quarter hours in meteorology and oceanography, to include at least twenty hours in the 4000 series, with a minimum of one 4000 level course in other than directed study.
  b. The basic sequence of graduate courses in the fields of dynamical, physical and synoptic meteorology/oceanography must be included in the forty-eight hours.
  c. Completion of an acceptable thesis on a topic approved by either department.

DOCTOR OF PHILOSOPHY

Department of Oceanography admission requirements for the degree of Doctor of Philosophy include:

  a. A Master's degree (or the equivalent) in physical science, mathematics, or engineering or
  b. A Bachelor's degree with a high QPR or
  c. A highly successful first graduate year in a Master's program, with clear evidence of research ability.

The Ph.D. Program is in Physical Oceanography, including areas of study in ocean circulation theory, ocean prediction, and ocean acoustics, among others.

A student who plans to undertake doctoral work in oceanography must discuss these plans with the Chairman, Department of Oceanography, who is authorized to admit students to doctoral programs. Regular guidelines, as outlined by the Department of Oceanography, should then be followed.

LABORATORY FACILITIES

The vast computational, data archival, and satellite image processing resources of the School, Naval Environmental Prediction Research Facility, and Fleet Numerical Oceanography Center are available.

The Department has a variety of physical oceanographic and MC&G laboratories.

DEPARTMENTAL COURSE OFFERINGS

OCEANOGRAPHIC SCIENCES

OC 0110, 0111, 0112, 0113 Application Seminars (1-0).
Presentation of DOD related research activities, applications to weapons and warfare systems, utilization of oceanography and meteorology in specific billets, presentations by faculty, staff, selected students, visiting authorities. OC 0110 is for orientation; OC 0111 is for intermediate students; OC 0112/0113 is for thesis orientation/topic selection. PREREQUISITE: Enrollment in an Air-Ocean Science curriculum.

OC 0810 Thesis Research (0-0).
Every student conducting thesis research will enroll in this course.

OC 0999 Seminar in Oceanography (2-0).
Students in the various oceanography curricula present their theses for discussion. PREREQUISITE: Preparation of a thesis.

Upper Division Courses

OC 2001 Ocean Systems (4-0).
This course is designed to support the Intelligence curriculum by providing an overview of significant oceanographic factors, data networks and their products, sound propagation in the ocean, active and passive sonar, and ocean vehicle design practices.

OC 2020 Computer Computations in Air-Ocean Sciences (1-2).
Introduction to FORTRAN, and the NPS main frame computer, as applied to elementary problems in oceanography and meteorology. PREREQUISITES: Calculus and college physics.

OC 2120 Survey of Oceanography (4-0).
An integrated view of the whole field of oceanography including physical, biological, geological, and chemical aspects. PREREQUISITES: None.

OC 2520 Survey of Air-Ocean Remote Sensing (3-0).
Overview of systems for remote sensing of the atmosphere and oceans from space, and operational applications. PREREQUISITES: Undergraduate physics and calculus, or consent of Instructor.

Upper Division or Graduate Courses

OC 3120 Biogeochemical Processes in the Ocean (4-3).
Basic biological, geological, and chemical processes in the ocean. Bioacoustics, deep scattering layers, and bio-deterioration. Geomorphic features of the ocean floor; kinds and distribution of ocean bottom features. Chemical composition of the ocean.

OC 3130 Mechanics of Fluids (4-2).
Fundamentals of the mechanics of fluids as a basis for geophysical fluid dynamics: introduction to field concepts, conservation principles, forces and effects, stress and rate of strain, momentum, energy, irrotational flow, introduction to turbulence and boundary-layer flow. Emphasis on problem solving. PREREQUISITE: MA 2121 equivalent (may be concurrent).

OC 3140 Probability and Statistics for Air-Ocean Science (3-2).
Basic probability and statistics, in the air-ocean science context. Techniques of statistical data analysis. Structure of a probability model, density, distribution function, expectation and variance. Binomial, Poisson and Gaussian distributions. Conditional probability and independence. Joint distributions, covariance and central limit theorem. Transformations of random variables. Histograms and empirical distributions and associated characteristics such as moments and percentiles. Standard tests of hypotheses and confidence intervals for both one and two parameter situations. Regression analysis as related to least squares estimation. PREREQUISITE: Calculus.

OC 3150 Analysis of Air Ocean Time Series (3-2).
Analysis methods for atmospheric and oceanic time series. Correlation, spectrum, and empirical orthogonal function analyses. Statistical objective analysis. Optimal design of air-ocean data networks. PREREQUISITES: MA 2121 and a probability and statistics course.

OC 3212 Polar Meteorology/Oceanography (3-1).
Operational aspects of arctic and antarctic meteorology. Polar oceanography. Sea ice; its seasonal distribution, melting and freezing processes, physical and mechanical properties, drift and predictions. Aspects of geology and geophysics. PREREQUISITES: MR 3222, OC 3240, or consent of Instructor.

OC 3230 Oceanic Thermodynamics (3-1).
Physical properties of seawater. Processes influencing the distribution of heat, salt, and density in the ocean. Static and dynamic stability in the ocean. PREREQUISITES: Calculus (may be concurrent) and college physics.

OC 3240 Ocean Circulation Analysis (4-2).
Static and dynamic stability in the ocean. Currents without friction: application of geostrophy, thermal wind. Wind-driven and frictional currents: Reynolds equations; Ekman solution; Sverdrup transport. Potential vorticity: westward intensification and topographic steering. Computational and computer graphics analysis laboratory. PREREQUISITES: OC 3230, OC 3321.

OC 3260 Sound in the Ocean (3-0).
Designed for students in the Hydrographic Sciences curriculum. A brief introduction to the physics of underwater acoustics followed by a detailed discussion of oceanographic factors affecting sound transmission in the ocean including absorption, reflection, refraction, scattering, and ambient noise. Emphasis placed on acoustic depth sounding, sea floor mapping, etc. for the hydrographic scientist. PREREQUISITE: OC 3230.

OC 3261 Oceanic Factors in Underwater Sound (4-0).
Examines the oceanic factors which influence sound propagation in the ocean and the effects these factors have in acoustic forecasting. Factors considered include temporal and spatial variations in sound speed

profiles, ambient noise, biological effects, reflection characteristics of ocean surface and bottom, signal fluctuations, and forecasting ocean thermal structure, transmission loss, and ambient noise. This course is designed for the Engineering Acoustics Curriculum. PREREQUISITES: PH 3452 and OC 2120.

OC 3321 Air-Ocean Fluid Dynamics (4-0).
The hydrodynamical equations for a rotating stratified fluid. Forces, kinematics, boundary conditions, scale analysis. Simple balanced flows, barocliniesty, thermal wind, vorticity and divergence; rotational and divergent part of the wind; circulation theorem. Vorticity and potential vorticity. PREREQUISITE: MA 2047 may be concurrent or equivalent.

OC 3325 Marine Geophysics (3-0).
Theory and methods of marine geophysics surveys, and emphasis on gravity, magnetism, seismic and acoustic wave propagation, heat flow, and radioactivity; geophysical anomalies associated with major seafloor features; acoustic reflectivity of the sea floor; marine geodesy. PREREQUISITE: MA 2121 (may be concurrent).

OC 3440 Small Oceanic Processes (2-2).
Introduction to concepts and information about turbulence in the ocean. A survey of measurement techniques and available data is used to study small scale mixing processes and their relationship to internal waves, double diffusion, turbulence generation, and energy dissipation. The role of turbulence in the dynamics and energetics of the ocean. PREREQUISITE: OC 3230.

OC 3445 Oceanic and Atmospheric Observational Systems (2-2).
Principles of measurement: sensors, data acquisition systems, calibration, etc. Methods of measurement for thermodynamic and dynamic variables in the ocean and atmosphere, including acoustics and optics. PREREQUISITES: OC 3230 and MR 3420.

OC 3520 Remote Sensing of the Atmosphere and Ocean (4-0).
Principles of radiative transfer and satellite sensors and systems; visual, infrared and microwave radiometry, and radar systems; application of satellite remotely-sensed data in the measurement of atmospheric and oceanic variability. PREREQUISITE: undergraduate physics and differential/integral calculus; ordinary differential equations or consent of Instructor.

OC 3522 Remote Sensing of the Atmosphere and Ocean with Laboratory (4-2).
Same as OC 3520 plus laboratory sessions on the concepts considered in the lecture series. PREREQUISITE: Same as OC 3520.

OC 3610 Wave and Surf Forecasting (2-2).
Theory and prediction of wind-generated ocean waves. Spectral transformation of waves from deep to shallow water. Prediction of surf and wave related influences on operations. PREREQUISITES: OC 3150, OC 4211.

Graduate Courses

OC 4211 Dynamical Oceanography (3-0)
Linear theory of surface and internal waves; theory of finite amplitude waves; windwave spectra. Inertial-internal, Rossby, and Kelvin waves. PREREQUISITES: OC/MR 3150 (may be concurrent), MA 3132, OC 3240.

OC 4212 Tides (4-0).
Development of the theory of tides including the tide-producing forces, equilibrium tides, and the dynamic theory of tides; harmonic analysis and prediction of tides; tidal datum planes and their relationship with geodetic datum planes, short-term and secular changes in sea level. PREREQUISITE: OC 3130 or OC 4211.

OC 4213 Nearshore and Wave Processes (3-1).
Shoal-water wave processes, breakers and surf; nearshore water circulation; beach characteristics; littoral drift; coastal hydraulics; storm surge. PREREQUISITE: OC 4211 or consent of instructor.

OC 4220 Shallow Water Oceanography (3-0).
Circulation and exchange processes of continental shelf and slope regions, shallow seas, and straits. Dynamics and models of coastal ocean circulations driven by wind, thermohaline, tidal, boundary current, and ocean eddy forces. PREREQUISITES: OC 3240 (may be concurrent), OC 4211, OC/MR 3321, and OC/MR 4413.

OC 4250 General Circulation of the Atmosphere and Oceans (3-0).
Selected topics on the general circulation of the atmosphere (e.g., heat, momentum and moisture fluxes; energetics) and ocean (e.g., linear and nonlinear theories of the wind-driven ocean circulation, nonlinear thermocline theories, mesoscale eddies, mixed-layer theories); coupled ocean-atmosphere general circulation models. PREREQUISITE: Consent of Instructor.

OC 4267 Ocean Influences and Prediction: Underwater Acoustics (4-3).
Examines sound speed profiles (time and space variability), ambient noise, absorption, and reflection from the sea surface and bottom as they affect sound propagation in the ocean. Synoptic prediction techniques for ambient noise and transmission loss are reviewed. Environmental data input and computational approximations for acoustic models are evaluated against observed signal fluctuations and transmission loss. The course is designed for the Air-Ocean Science, Operational Oceanography, and ASW curricula. PREREQUISITES: OC 2120, PH 2471, concurrent enrollment in PH 3472 or OC3240 and PH 3431; SECRET clearance.

OC 4323 Numerical Air and Ocean Modeling (4-2).
Numerical models of atmospheric and oceanic phenomena. Finite difference techniques for solving elliptic and hyperbolic equations, linear and nonlinear computational instability. Spectral and finite element models. Filtered and primitive equation prediction models. Sigma coordinates. Objective analysis and initialization. Moisture and heating as time permits. PREREQUISITES: MR 4322, MA 3132, and MA 3232 desirable.

OC 4331 Synoptic/Mesoscale Oceanography (3-0).
Contemporary knowledge of synoptic/mesoscale ocean variability. Kinematics, dynamics, and energetics of cyclonic and anticyclonic ocean eddies, ocean fronts, and meandering currents; their geographical and statistical distribution. Methods of observation and practical application. PREREQUISITES: OC 3240, OC/MR 3321, OC/ MR 3150 (may be concurrent).

OC 4335 Elements of Ocean Prediction (3-2).
Analyze, forecast, and interpret synoptic information on mesoscale, synoptic scale, and large scale processes on a regional basis. Use is made of dynamical and statistical principles and methods and of diagnostic and prognostic models. PREREQUISITE: OC 4330 and OC/MR 4323 (may be concurrent).

OC 4413 Air/Sea Interaction (4-0).
Fundamental concepts in turbulence. The atmospheric planetary boundary layer, including surface layer, and bulk formulae for estimating air-sea fluxes. The oceanic planetary boundary layer including the dynamics of the well-mixed surface layer. Recent papers on large-scale air-sea interaction. PREREQUISITE: OC 3240 or MR 4322 (may be concurrent) or consent of Instructor.

OC 4414 Advanced Air/Sea Interaction (3-0).
Advanced topics in the dynamics of the atmospheric and oceanic planetary boundary layers. PREREQUISITE: OC/MR 4413 or consent of Instructor.

OC 4430 Operational Oceanography of US/USSR Acoustical Surveillance Systems (3-0).
Advanced topics in the application of oceanographic and acoustic principles to specific operational US/USSR surveillance systems. Environmental acoustic limits on figure of merit, signal to noise ratio, performance index, median detection range, reliable acoustic path range, probability of detection, convergence zone and ducting are established in different oceanic regimes and operational scenarios. Advanced environmental acoustic modelling (FACT, PE, ASTRAL, AND DANES models) is introduced to compare the environmental acoustic effects on systems and to illustrate model limitations in establishing predicted operational performance. Emphasis on classified student projects and use of visiting undersea surveillance authorities. PREREQUISITES: USN officers only, consent of Instructor.

OC 4520 Topics in Satellite Remote Sensing (3-0).
Selected topics in the advanced application of satellite remote sensing to the measurement of atmospheric and oceanic variables. PREREQUISITE: OC/MR 3522.

OC 4610 Soviet Oceanography (1-2).
Soviet civilian and naval oceanography and meteorology. The oceanography of soviet waters. Includes lectures, library research, and a term paper. SECRET clearance required. PREREQUISITE: OC 3240 and MR 3220 or equivalent.

OC 4800 Advanced Topics in Oceanography (1-0 to 4-0).
Advanced topics in various aspects of oceanography. Topics not covered in regularly offered courses. The course may be repeated for credit as topics change. PREREQUISITE: Consent of the Department Chairman and Instructor.

OC 4900 Special Topics in Oceanography (1-0 to 4-0).
Independent study of advanced topics in oceanography not regularly offered. PREREQUISITE: Consent of the Department Chairman and Instructor.

HYDROGRAPHIC SCIENCES

Lower Division Courses

GH 1101 Nautical Science for Hydrographers (2-0).
Basic principles of nautical science for hydrographers with little or no previous sea experience. Topics include piloting and navigation, celestial navigation, rules of the road, use of radar, radar plotting, small boat handling, ship capabilities, seamanship, emergency procedures, safety at sea, marine communications and magnetic and gyro compasses.

Upper Division or Graduate Courses

GH 3901 Mapping, Charting, and Geodesy (4-2).
Principles and fundamentals of geodesy, photogrammetry, and cartography. The application of these disciplines to mapping and charting with emphasis on the propagation of random errors inherent in each phase: data acquisition, data reduction, generalization, and portrayal.

GH 3902 Hydrographic and Geodetic Surveying (4-2).
Principles and applications of hydrographic and geodetic surveying. Introduction to surveying procedures, both at sea and on land, including use of surveying instruments. PREREQUISITE: GH 3901.

GH 3903 Electronic Surveying and Navigation (4-0).
Introduction to the theory and practice of electronic surveying and navigation including principles of electronics, electronic surveying systems and basic components, geometry of electronic surveying, ray path curvature, propagation velocity, and velocity applications to surveying. PREREQUISITE: GH 3902.

GH 3906 Hydrographic Survey Planing (2-2).
Planning and management of a hydrographic survey project. Gathering of sufficient background data (geodetic control, historic tide station locations) and its implementation in planning a complete basic hydrographic survey of Monterey Bay. PREREQUISITES: GH 3902.

GH 3910 Hydrographic Surveying Field Experience (2-9).
Conduct a basic hydrographic survey of a portion of Monterey Bay. Field work consists of locating horizontal control stations through photogrammetric methods, installing and monitoring a tide gage, and running sounding lines using various types of positioning control. Data acquisition, reduction, and presentation will be emphasized. PREREQUISITES: GH 3906 and concurrent registration in GH 3911.

GH 3911 Geodetic Surveying Field Experience (1-5).
Conduct a geodetic survey project in the Monterey Bay area to support GH 3910. Methods include angulation, trilateration, traverse, resection, and intersection. Azimuth determination by observation on Polaris. PREREQUISITES: GH 3906 and concurrent registration in GH 3910.

GH 3912 Advanced Hydrography (2-2).
Contemporary aspects of hydrographic methods. Subjects include tidal current measurements, satellite navigation, inertial navigation, side-scan sonar, photobathymetry, laser bathymetry, and automation in hydrography. Laboratory exercise includes planning a hydrographic survey project. PREREQUISITES: GH 3903, GH 3910, and GH 3911; or consent of the Instructor.

GH 3914 Adjustment Computations (4-0).
Solution and analysis of geodetic networks and photogrammetric problems using least squares with matrices. Variance and covariance. Weights. Condition and observation equations and combinations. Statistical tests. PREREQUISITE: MA 2047.

GH 3950 Naval Astronomy and Precise Time (2-0).
Positional astronomy. Coordinate systems. Solar system dynamics. Astrometry (measurements of positions and motions of stars). Time, earth rotation, and atomic clocks. Naval applications of astronomy. Overview of astrophysics and cosmology. PREREQUISITES: College physics and calculus.

Graduate Courses

GH 4800 Advanced Topics in Geodetic Science (1-0) to (4-0).
Advanced topics in various aspects of the geodetic sciences. Topics not covered in regularly offered courses..The course may be repeated for credit as topics change. PREREQUISITES: Consent of the Department Chairman and Instructor.

GH 4906 Geometric and Astronomic Geodesy (4-0).
Properties of the ellipsoid, geometric aspects of geodesy including triangulation, trilateration, traverse, and leveling techniques and instrumentation; adjustment by least squares, astronomic determination of latitude, longitude, and azimuth; time and astronomic instrumentation. PREREQUISITES: OC 3325 and GH 3902.

GH 4907 Gravimetric and Satellite Geodesy (4-0).
Potential theory as applied to the gravity field of the earth; application of Stokes' Formula, integral, and function; deflection of the vertical; gravimetric reduction; geometric and dynamic applications of satellites, orbital geometry and satellite orbit dynamics. PREREQUISITE: GH 4906.

GH 4908 Photogrammetry and Remote Sensing (3-2).
Application of photogrammetric instruments and techniques to planimetric, topographic, and hydrographic data compliation. Use of analog, semi-analytical, and analytical photogrammetry in geodetic control extension. Planning and execution of aerial photography. Principles and fundamentals of remote sensing. Application of remote sensing imagery to mapping and charting. PREREQUISITE: GH 3902.

DEPARTMENT OF OPERATIONS RESEARCH

Alan Robert Washburn, Professor of Operations Research; Chairman (1970);* B.S., Carnegie Institute of Technology, 1962; M.S., 1963; Ph.D., 1965.

Alvin Francis Andrus, Associate Professor of Operations Research and Statistics (1963); B.A., Univ. of Florida, 1957; M.A., 1958.

Donald Roy Barr, Professor of Operations Research and Statistics (1966); B.A., Whittier College, 1960; M.S., Colorado State Univ., 1962; Ph.D., 1965.

Gerald Gerard Brown, Professor of Operations Research (1973); B.A., California State Univ. at Fullerton, 1968; M.B.A., 1969; Ph.D., Univ. of California at Los Angeles, 1974.

James Norfleet Eagle, II, Associate Professor of Operations Research (1982); B.S., U.S. Naval Academy, 1969; M.S., Stanford Univ., 1973; Ph.D., 1975.

James Daniel Esary, Professor of Operations Research and Statistics (1970); A.B., Whitman College, 1948; M.A., Univ. of California at Berkeley, 1951; Ph.D., 1957.

Paul Stelling Fishbeck, Lieutenant Commander, U.S. Navy; Instructor of Operations Research (1983); B.Sc., Univ. of Virginia, 1974; M.Sc., Naval Postgraduate School, 1981.

Robert Neagle Forrest, Professor of Operations Research (1964); B.S., Univ. of Oregon, 1950; M.S., 1952; M.S., 1954; Ph.D., 1959.

Jack Burton Gafford, Major, U.S. Army; Instructor of Operations Research (1984); B.Sc., U.S. Military Academy, 1969; M.Sc., Naval Postgraduate School, 1976.

Donald Paul Gaver, Jr., Distinguished Professor of Operations Research and Statistics (1971); S.B., Massachusetts Institute of Technology, 1950; S.M., 1951; Ph.D., Princeton Univ., 1956.

James Kern Hartman, Associate Professor of Operations Research (1970); B.S., Massachusetts Institute of Technology, 1965; M.S., Univ. of Nebraska, 1967; Ph.D., Case Western Reserve Univ., 1970.

Gilbert Thoreau Howard, Associate Professor of Operations Research (1967); B.S., Northwestern Univ., 1963; Ph.D., Johns Hopkins Univ., 1967.

Wayne Philo Hughes, Jr., Adjunct Professor of Operations Research (1979); B.S., U.S. Naval Academy, 1952; M.S., Naval Postgraduate School, 1964.

Charles Willis Hutchins, Jr., Commander, U.S. Navy; Assistant Professor of Man-Machine Systems (1982); B.A., Los Angeles State College, 1961; M.A., 1963; Ph.D., Ohio State Univ., 1970.

Patricia Anne Jacobs, Associate Professor of Operations Research (1978); B.S., Northwestern Univ., 1969; M.S., 1971; Ph.D., 1973.

Harold Joseph Larson, Professor of Operations Research and Statistics (1962); B.S., Iowa State Univ., 1956; M.S., 1957; Ph.D., 1960.

Peter Adrian Walter Lewis, Professor of Operations Research and Statistics (1971); B.A., Columbia College, 1954; B.S., Columbia Engineering School, 1955; M.S., 1957; Ph.D., Univ. of London, 1964.

Glenn Frank Lindsay, Associate Professor of Operations Research (1965); B.Sc., Oregon State Univ., 1960; M.Sc., Ohio State Univ., 1962; Ph.D., 1966.

Alan Wayne McMasters, Associate Professor of Operations Research and Administrative Sciences (1965); B.S., Univ. of California at Berkeley, 1957; M.S., 1962; Ph.D., 1966.

Kneale Thomas Marshall, Professor of Operations Research (1968); B.Sc. (Eng.), Imperial College, London, 1958; M.S., Univ. of California at Berkeley, 1964; Ph.D., 1966.

Paul Robert Milch, Professor of Operations Research and Statistics (1963); B.S., Brown Univ., 1958; Ph.D., Stanford Univ., 1966.

Douglas Elmer Neil, Assistant Professor of Operations Research (1972); B.A., Univ. of Southern California, 1965; M.S., Univ. of Pacific, 1967; Ph.D., North Carolina State Univ., 1971.

Samuel Howard Parry, Associate Professor of Operations Research (1973); B.S., Georgia Institute of Technology, 1963; M.S., Northwestern Univ., 1964; Ph.D., Ohio State Univ., 1971.

Frank Marchman Perry, Major, U.S. Army, Instructor in Operations Research (1983); B.S., U.S. Military Academy (1967); M.S., Naval Postgraduate School (1975).

Gary Kent Poock, Professor of Operations Research and Man-Machine Systems (1967); B.S., Iowa State Univ., 1961; M.S., Univ. of Miami, 1965; Ph.D., Univ. of Michigan, 1967.

Robert Richard Read, Professor of Operations Research and Statistics (1961); B.S., Ohio State Univ., 1951; Ph.D., Univ. of California at Berkeley, 1957.

Francis Russell Richards, Associate Professor of Operations Research (1970); B.S., Louisana Polytechnic Institute, 1965; M.S., Clemson Univ., 1967; Ph.D., 1971.

Edward Brandt Rockower, Adjunct Professor of Operations Research (1984); B.S., Univ. of California, Los Angeles, 1964; M.A., Brandeis Univ., 1967; Ph.D., 1975.

Richard Edwin Rosenthal, Associate Professor of Operations Research (1985); B.A., Johns Hopkins Univ., 1972; Ph.D., Georgia Institute of Technology, 1975.

David Alan Schrady, Professor of Operations Research (1965); B.S., Case Institute of Technology, 1961; M.S., 1963; Ph.D., 1965.

Bruno Otto Shubert, Associate Professor of Operations Research, Probability, and Statistics (1970); M.S., Czech. Technical Univ. at Prague, 1960; Ph.D., Charles Univ. at Prague, 1964; Ph.D., Stanford Univ., 1968.

Rex Hawkins Shudde, Associate Professor of Operations Research (1962); B.A. and B.S., Univ. of California at Los Angeles, 1952; Ph.D., Univ. of California at Berkeley, 1956.

Armando Raul Solis, Commander, U.S. Navy; Instructor in Operations Research (1984); B.Sc., U.S. Naval Academy, 1967; M.Sc., Naval Postgraduate School, 1973.

Michael Graham Sovereign, Professor of Operations Research (1970); B.S., Univ. of Illinois, 1959; M.S., Purdue Univ., 1960; Ph.D., 1965.

Joseph Stanley Stewart II, Commander, U.S. Navy; Instructor in Operations Research (1984); B.Sc., U.S. Naval Academy, 1966; M.Sc., Naval Postgraduate School, 1973.

Timothy John Sullivan, Commander, U.S. Navy; Instructor of Operations Research (1984); B.S., U.S. Naval Academy, 1967; M.S., Naval Postgraduate School, 1973.

James Grover Taylor, Professor of Operations Research (1968); B.S., Stanford Univ., 1961; M.S., 1962; Ph.D., 1966.

Joseph Bryce Tysver, Adjunct Professor of Operations Research and Statistics (1966); B.A., Washington State Univ., 1942; M.A., 1948; Ph.D., Univ. of Michigan, 1957.

Roger Kevin Wood, Assistant Professor of Operations Research (1982); B.Sc., Electrical Engineering and Mathematics, Univ. of Portland, 1977; M.Sc., Operations Research, Columbia Univ., 1978; Ph.D., Operations Research, Univ. of California, Berkeley, 1982.

James R. Yee, Adjunct Professor of Operations Research; (1983) B.E.E., The City College of New York, 1971; S.M., Massachusetts Institute of Technology, 1974; E.E., 1976.

Peter William Zehna, Professor of Operations Research and Statistics (1961); B.A., Colorado State College, 1950; M.A., 1951; M.A., Univ. of Kansas, 1956, Ph.D., Stanford Univ., 1959.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES

Programs leading to degrees must be rarranged in consultation with the Chairman, Department of Operations Research.

MASTER OF SCIENCE IN APPLIED SCIENCE

Students with acceptable academic backgrounds may enter a program leading to the degree in Applied Science with major in Operations Research. The program of each student seeking this degree must contain a minimum of 20 quarter hours in operations research at the graduate level, including work at the 4000 level. Additionally,

the program must contain a minimum of 12 graduate quarter hours in an approved sequence of courses outside the Department of Operations Research. A total minimum of 12 quarter hours at the 4000 level plus an acceptable thesis is required. This program provides depth and diversity through specially arranged course sequences to meet the needs of the Navy and the interests of the individual. The Department Chairman's approval is required for all programs leading to this degree.

MASTER OF SCIENCE IN OPERATIONS RESEARCH

1. A candidate shall previously have satisfied the requirements for the degree of Bachelor of Science in Operations Research or the equivalent.

2. Completion of a minimum of 40 quarter hours of graduate level courses with:

    a. At least 18 quarter hours of 4000 level operations research/systems analysis courses.
    b. An elective sequence approved by the Department of Operations Research.
    c. At least two but not more than three quarter courses devoted for a thesis.

3. Submission of an acceptable thesis on a subject previously approved by the Department of Operations Research. This credit shall not count toward the requirement stated in 2a.

4. In addition to the school wide requirement of a 3.00 minimum quality point rating for graduate level courses, the candidate must achieve a minimum of 2.75 quality point rating in all graduate level courses programmed for the first six quarters.

DOCTOR OF PHILOSOPHY

The department offers the Ph.D. degree in Operations Research. The program begins with advanced coursework guided by the student's doctoral committee and leading to qualifying examinations in mathematical programming, statistics, and stochastic processes. The primary emphasis then shifts to the student's research program culminating in the Ph.D. dissertation.

Students wishing to enter directly into the doctoral program should write to the department chairman. Detailed admission procedures may vary depending on the individual's location and position. However, in all cases the student must fulfill the general school requirements for the Doctor's degree.

DEPARTMENTAL COURSE OFFERINGS

OPERATIONS ANALYSIS

OA 0001 Seminar for Operations Analysis Students (0-2).
Guest lecturers. Review of experience tours. Thesis and research presentations.

OA 0810 Thesis Research for Operations Analysis Students (0-0).
Every student conducting thesis research will enroll in this course.

Upper Division Courses

OA 2200 Computational Methods for Operations Research (3-2).
Introduction to computer usage with emphasis on computational methods particularly appropriate for operations research. Planning and structuring computer programs. Programming in FORTRAN. Use of text editor, disk files, subroutine libraries, and debugging aids in timesharing mode on mainframe computers. Extensive project work coordinates growing student FORTRAN knowledge with topics in OR computing. Project topics may include numerical error analysis, probability distributions, random sampling, matrix computations, search methods, and OR modelling. PREREQUISITES: None.

OA 2600 Introduction to Operations Analysis (4-0).
A first course in Operations Analysis, covering its early origins through World War II to current practice. Introduces concepts, tools and methods of analysis, with emphasis on tactical problems. Emphasis is placed on readiness and weapon systems performance, both singly and in combination. *Graded on Pass/Fail basis only.*

OA 2910 Selected Topics in Operations Analysis (2-0 to 5-0).
Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background in operations research.

Upper Division or Graduate Courses

OA 3101 Probability (4-1).
Probability axioms and event probability. Random variables and their probability distributions. Moment generating functions, moments and other distribution characteristics, distribution families. Functions of a random variable, including the probability integral transformation. Chebychev inequality, law of large numbers. PREREQUISITE: MA 1115 or equivalent.

OA 3102 Probability and Statistics (4-1).
Jointly distributed random variables, independence and conditional distributions, covariance and correlation. Functions of several random variables, sampling distributions, limiting distributions, the central limit theorem, approximations. Order statistics, the t and F distributions, the bivariate normal distribution. Point estimation, properties of estimators, interval estimation. PREREQUISITES: OA 3101 and MA 1116 or equivalent; MA 2110 taken concurrently.

OA 3103 Statistics (4-1).
Confidence intervals, Bayesian intervals, hypothesis testing, significance testing. Regression, analysis of variance, nonparametic inference. Applications to reliability, test and evaluation, and operations research problems. PREREQUISITE: OA 3102 or equivalent.

OA 3104 Data Analysis (3-1).
Techniques of analyzing real data. The exploratory nature of data analysis is featured through a variety of plotting methods and interactive work on the computer terminals. Includes model building, and the discovery and overcoming of shortcomings in data collected in actual situations. PREREQUISITE: OA 3103.

OA 3201 Linear Programming (4-0).
Theory of optimization of linear functions subject to linear constraints. The simplex algorithm, duality, dual simplex algorithm, sensitivity analyses, parametric linear programming, transportation algorithm and matrix payoff games. Applications to resource allocation, manpower planning, transportation and communications network models, ship scheduling, and elementary strategic games. Introduction to machine computing and MPS. PREREQUISITE: MA 2042, MA 2110 taken concurrently, and FORTRAN or equivalent.

OA 3301 Stochastic Models I (4-0).
The homogeneous and inhomogeneous Poisson process, filtered and compound Poisson process. Stationary Markov chains and their applications in modelling random phenomena. PREREQUISITE: OA 3102.

OA 3302 System Simulation (4-0).
Discrete event digital simulation methodology. Monte Carolo techniques, use of FORTRAN and other available simulation languages. Variance reduction techniques, design of simulation experiments and analysis of results. PREREQUISITES: OA 2200 or equivalent; OA 3103 or equivalent.

OA 3401-3402 Human Factors in Systems Design I-II (4-0 and 3-0).
The human element in man-machine systems. Selected topics in human engineering and psychophysics with emphasis on their relation to military systems. Man-machine interface and man's motor and sensory capacities. PREREQUISITE: A course in statistics.

OA 3501 Inventory I (4-0).
A study of deterministic and approximate stochastic inventory models. Deterministic economic lot size models with infinite production rate, constraints, quantity discounts. An approximate lot size-reorder point model with stochastic demand. An approximate stochastic periodic review model. Single period stochastic models. Applications to Navy supply systems. PREREQUISITE: OA 3102 or equivalent.

OA 3601 Combat Models and Games (4-1).
This course provides an introduction to five specific techniques that find common use in modelling combat. These techniques include Decision/Utility Theory, Resursive Solution Techniques, Lanchester Systems, Coverage Problems, and Game Theory.

OA 3602 Search Theory and Detection (4-0).
Search and detection as stochastic processes. Characterization of detection devices, use and interpretation of sweep widths, lateral range curves, true range curves. Measures of effectiveness of search-detection systems. Allocation of search effort, sequential search. Introduction to the statistical theory of signal detection. Models of surveillance fields, barriers, tracking, and trailing. PREREQUISITES: OA 3301, PH 3321.

OA 3800 Quantitative Communications (2-2).
This course deals with the effective construction and presentation of reports on quantative analyses, with emphasis on graphical aspects. Students will be expected to review, criticize, summarize, and give written and verbal reports about selected studies.

OA 3900 Workshop in Operations Research/Systems Analysis (2-0 to 5-0).
This course may be repeated for credit if course content changes. PREREQUISITE: Departmental approval. *Graded on Pass/Fail basis only.*

OA 3910 Selected Topics in Operations Research/Systems Analysis (2-0 to 5-0).
Presentation of a wide selection of topics from the current literature. This course may be repreated for credit if course content changes. PREREQUISITE: A background of advanced work in operations research. Consent of Instructor.

Graduate Courses

OA 4101 Design of Experiments (3-1).
Theory and applications of the general linear hypothesis model. Analysis of variance and analysis of covariance. Planning experiments, traditional and hybrid experimental designs. Use of standard computer package for analysis of experimentation data. PREREQUISITE: OA 3103 or equivalent.

OA 4102 Regression Models (4-0).
Construction, analysis and testing of regression models. An in-depth study of regression and its application in operations research, economics and the social sciences. PREREQUISITES: OA 3102, OA 3103, OA 3104.

OA 4103 Advanced Probability (3-0).
Probability spaces, random variables as measurable functions, expectation using the Lebesque Stieltjes integral and abstract integration. Modes of convergence, characteristic functions, the continuity theorem, central limit theorems, the zero-one law. Conditional expectation. PREREQUISITE: MA 3605 or departmental approval.

OA 4104 Advanced Statistics (3-0).
Foundations of statistics from a decision-theoretic viewpoint. Robust estimation techniques, biased estimation, Fisher's and Kullback information, asymptotic methods. Sufficiency, completeness, the Cramer-Rao inequality. Sequential tests, empirical Bayes tests. Statistical computation methods. PREREQUISITE: OA 3103 and consent of Instructor.

OA 4105 Nonparametric Statistics (4-0).
Tests based on the binomial distribution; confidence intervals for percentiles, tolerance intervals and goodness-of-fit tests; contingency tables; one sample tests, two sample tests and tests for independence based on ranks and scores; nonparametric analysis of variance and regression. Applications will illustrate the techniques. PREREQUISITE: OA 3103.

OA 4201 Nonlinear and Dynamic Programming (4-0).
Introduction to modern optimization techniques and multistage decision processes. Kuhn-Tucker necessary and sufficient conditions for optimality, quadratic and separable programming, basic gradient search algorithms, penalty function methods and dynamic programming. Applications to weapons assignment, force structuring, parameter estimation for nonlinear or constrained regression, personnel assignment and resource allocation. PREREQUISITE: OA 3201, MA 2110.

OA 4202 Networks Flows and Graphs (4-0).
Introduction to formulation and solution of problems involving networks. Elements of graph theory, data structures, search algorithms, max-flow min-cut theorem, shortest route problems, minimum cost flows, and PERT/CPM. Applications to production and inventory, routing, scheduling, network interdiction, and personnel assignment. PREREQUISITE: OA 3201.

OA 4203 Mathematical Programming (4-0).
Advanced topics in linear programming. Large scale systems, the decomposition principle, additional algorithms, bounded variable techniques, linear fractional programming, probabilistic programming, formulation and solution procedures for problems in integer variables. Applications to capital budgeting, large scale distribution systems, weapon systems allocation and others. PREREQUISITE: OA 3201.

OA 4204 Games of Strategy (4-0).
Mathematical models of conflict situations, emphasizing the theory of decision making against a completely opposed enemy. Applications to ASW, system acquisition, and other solutions to games that are partly cooperative. PREREQUISITES: OA 3101, OA3201.

OA 4205 Nonlinear Programming (4-0).
Continuation of OA 4201. Advanced topics in nonlinear programming including duality theory, further consideration of necessary and sufficient conditions for optimality, additional computational methods and examination of recent literature in nonlinear programming. PREREQUISITE: OA 4201.

OA 4206 Dynamic Programming (4-0).
A continuation of OA 4201. Basic theory of dynamic programming with numerous optimization and resource allocation applications in the areas of reliability design, target selection, inventory theory, project selection and others. D.P. in Markov chains. PREREQUISITE: OA 4201.

OA 4207 Optimization of Time-Sequential Processes (4-0).
Study of time-sequential decision processes. Modeling and optimization of dynamic systems with one or more decision makers. Applications of modern optimal control theory and differential games to problems of military operations research. Typical areas of application are time-sequential combat games (air-war allocation strategies, fire-support allocation strategies), inventory systems, searching for targets, strategic missile allocations, pursuit and evasion, engagement of targets of opportunity. PREREQUISITE: OA 4201 or consent of Instructor.

OA 4301 Stochastic Models II (3-2).
Course objectives are to teach methods of stochastic modeling beyond those taught in OA 3301 and to give students an opportunity to apply these tools to real world problems. Suitably selected projects that entail data collection and analysis are undertaken, with emphasis on problem formulation, choice of appropriate assumptions and attainment of practical results. The theory part of the course usually focuses on renewal processes and Kalman Filtering as illustrated by several military and industrial applications. PREREQUISITE: OA 3301.

OA 4302 Reliability and Weapons System Effectiveness Measurement (4-0).
Component and system reliability functions, and other descriptors for the reliability of system effectiveness. Relationships between system and component reliability. Point and interval estimates of reliability parameters under various life testing plans. Illustrations of current methods of reliability assessment from appropriate MIL-STD's and manuals. PREREQUISITE: OA 3301.

OA 4303 Sample Inspection and Quality Assurance (4-0).
Attribute and variables sampling plans. MIL-STD sampling plans with modifications. Multi-level continuous sampling plans and sequential sampling plans. Structure of quality assurance programs and analysis of selected quality assurance problems. PREREQUISITE: OA 3103 or consent of Instructor.

OA 4304 Decision Theory (3-0).
Basic concepts, Bayes, admissible, minimax, and regret strategies. Principles of choice. Relation of statistical decision functions to the theory of games. Applications in the planning of operational evaluation trials. PREREQUISITE: OA 3103.

OA 4305 Stochastic Models III (4-0).
Lecture topics include, non-stationary behavior of Markov processes, point process models, regenerative processes, Markovian queueing network models, and non-Markovian systems. Applications to include reliability, computer system modelling, combat modelling, and manpower systems. Students are given exercises entailing data analysis, formulation of probability models, and application of models to answer specific questions concerning particular phenomenon. PREREQUISITES: OA 3104, OA 3301, OA 4301.

OA 4306-4307 Stochastic Processes I-II (4-0).
The Kolmogorov theorem; analytic properties of sample functions; continuity and differentiability in quadratic mean; stochastic integrals, stationary processes. Stationary and non-stationary problems; Martingale limit theorems and the invariance principle. PREREQUISITE: OA 4103.

OA 4308 Time Series Analysis (4-0).
Second order stationary processes. Harmonic analysis of correlation functions. Filters and spectral windows. Ergodic properties. Problems of inference in time series analysis, Box-Jenkins techniques. Introduction to the analysis of multivariate processes. PREREQUISITE: Consent of Instructor.

OA 4321 Decision Support Systems (3-1).
An introduction to the topic; includes an overview of organizational decision making, discussion of OR techniques integral to DSS, relationships to artificial intelligence and expert systems, specialized computer languages, and non-traditional techniques for handling uncertainty. Current operational systems, both military and civilian, will be used as examples. PREREQUISITES: Any one of OA 3302, OS 3303, OS 3603.

OA 4401 Human Performance Evaluation (4-0).
Experimental considerations, strategy, and techniques in evaluation of human performance characteristics and capabilities. Detailed examination of special methods to include multivariate designs, psychophysical methods, and psychophysiological methods. Review of important variables affecting human performance and criteria, measures of effectiveness, and figures of merit as indicants of performance quality. PREREQUISITE: OA 3401.

OA 4402 Skilled Operator Performance (3-2).
First part of the course is devoted to an examination of the theoretical foundations of skilled performance. The second half of the course is devoted to the study of the acquisition, development and prediction of skilled operator performance in the operational setting. PREREQUISITE: OA 3401.

OA 4404 Operations Research in Man-Machine Systems (4-0).
Application of operations research techniques to man-machine design and evaluation problems. Quantitative methods for performance will be treated using such concepts as reliability, information theory, and signal detection theory. A portion of the course will be devoted to summarizing approaches to real world problems incorporating current methods from the literature. PREREQUISITES: OA 3401, OA 3201, OA 3301, and OA 4301 (may be taken concurrently).

OA 4501 Seminar in Supply Systems (4-0).
A survey of the supply system of the U.S. Navy. Topics include the inventory models at all levels for consumables and repairables, budget formulation and execution, provisioning and allowance lists, planned program requirements, transaction item reporting, and current topics of research such as stock migration and material distribution studies. PREREQUISITE: OA 3501.

OA 4502 Inventory II (4-0).
A study of stochastic inventory models. Single period models with time dependent costs, constrained multiple item single period models, deterministic and stochastic dynamic inventory models, the (r,R) periodic review model, the Q=1 continuous review model. PREREQUISITES: OA 3301, OA 3501.

OA 4601 Advanced Topics in War Gaming and Simulation (3-2).
A greater-depth coverage of material introduced in OA 3302 and OA 3601. Advanced techniques of model development and simulation experimentation. Discussion of current research. Actual topics selected will depend on interests of students and instructor. This course is particularly appropriate for those doing thesis in this area. PREREQUISITE: OA 3601 and departmental approval.

OA 4602 Campaign Analysis (4-0).
The development, use, and state of the art of Naval campaign analysis. Emphasis is placed on formulating the analysis, measures of effectiveness, handling assumptions, modeling hierarchies, and parametric tests. Specific ASW and AAW campaign models are examined, "capabilities" and "requirements" analyses are differentiated. The students will study and discuss major portions of actual analyses, such as SEAWAR-85, SEAPLAN 2000, TACNUC WAR AT SEA, SEAMIX III, SEA BASED AIR PLATFORM STUDY, and the MAJOR FLEET ESCORT STUDY. PREREQUISITES: OA 3103, OA 3301, OA 3302, OA 3601, OA 3602, OA 4604, and SECRET NOFORN clearance.

OA 4603 Test and Evaluation (3-2).
This course relates the theory and techniques of operations research to the problems associated with test and evaluation. Specific examples of exercise design, reconstruction, and analysis are examined. PREREQUISITES: OA 3104, OA 4604 or OA 4654.

OA 4604 War Gaming Analysis (4-0).
Analysis of problems in the design, construction and application of manual, computer and interactive gaming. Emphasis is on gaming as a means of evaluating Naval warfare tactics. The NWES and NAVTAG gaming facilities will be used. PREREQUISITES: OA 3302, OA 3601, and OA 3602. SECRET NOFORN clearance.

OA 4605 Operations Research Problems in Naval Warfare (3-0).
Analyses of fleet exercises. Changes in tactics and force disposition arising from the introduction of nuclear weapons and missiles. Relationship of air defense to strike capability and ASW. Current radar, sonar, communications, and ECM problems. PREREQUISITE: OA 3601 OA 4604.

OA 4606 Applications of Search, Detection and Localization Models to ASW (3-0).
Applications of search, detection and localization models to search planning, target localization procedures, and ASW sensor evaluation. Both acoustic and nonacoustic sensors are considered. PREREQUISITES: OS 3601 or OA 4604, U.S. Citizenship and SECRET clearance.

OA 4607 Tactical Design and Analysis (4-0).
Use of hand-held programmable calculators (HPCs) and their application to tactical problems in the operational environment. Characteristics of currently available HPCs will be discussed and compared with special emphasis on the use of their more sophisticated features. Methods for implementing environmental, search, localization, and tracking algorithms on the HPC. Individual and/or group projects allow the student to apply the concepts presented in class to problems in his area of expertise. PREREQUISITES: OA 3602 or OS 3601 or consent of Instructor and SECRET NOFORN clearance. *Graded on Pass/Fail basis only.*

OA 4608 Soviet Military Operations Research (4-0).
This course provides an introduction to Soviet military operations research (OR), with an emphasis on asymmetries in Soviet and American use of military OR. It will focus on how OR influences Soviet military theory and practice. It will begin by examining the Soviet military mind as influenced by the Russian/Soviet historical experience, Marxist-Leninist ideology, and Soviet social and military institutions. It will then trace the historical development of military OR in the Soviet Union and discuss its nature today. Topics include: textbooks for the selling and practice of military OR, Soviet combat models, network models for planning of combat operations, target-engagement models, models of reconnaissance/intelligence processes, modelling of deception, automated artillery fire planning, strategic models. Students will receive English translations of major Soviet works on military OR. PRE—REQUISITES: Course on combat modelling (e.g. OA 3601 or OA 4654) or consent of instructor, and SECRET NOFORN clearance.

OA 4654 Airland Combat Models I (4-0).
Introduction to modelling air/ground combat operations with emphasis on detailed approaches for modelling small-scale combat. Topics include: types of models, the modelling process, verification, target acquisition models, target selection, weapon accuracy, lethality models, terrain effects, tactical decision making, and integration of these models into large scale simulation models of combat. Models currently in use in DOD analysis are used as examples throughout the course. PREREQUISITE: OA 3301.

OA 4655 Airland Combat Models II (4-0).
Modelling of large scale air/ground combat operations using aggregated force on force combat models. Topics include: Aggregation and disaggregation, types of models used for large scale operations, firepower index and Lanchester equation approaches to attrition modeling, movement rate of advance models, air warfare models, and air allocation, logistics, C3 I process models, artificial intelligence applications. Models currently in use for DOD analysis are used as examples throughout the course. PREREQUISITE: OA 3301 or consent of the instructor.

OA 4701 Econometrics (4-0).
Construction and testing of econometric models, analysis of economic time series, and the use of multivariate statistical analysis in the study of economic behavior. PREREQUISITE: OA 3103.

OA 4702 Cost Estimation (4-0).
Advanced study in the methods and practice of systems analysis with emphasis on cost analysis; cost models and methods for total program structures and single projects; relationship of effectiveness models and measures to cost analyses; public capital budgeting of interrelated projects; detailed examples from current federal practices. PREREQUISITE: AS 3611 or equivalent.

OA 4703 Defense Expenditure and Policy Analysis (4-0).
A presentation of the major components of defense budgeting and policy formulation from the standpoint of the three major institutions involved, the agency, executive and congress. The use of quantitative models of institutional behavior is emphasized when examining both individual institutions and the interaction between them. PREREQUISITE: AS 3611.

OA 4704 OR Techniques in Manpower Modelling (4-0).
The most frequently applied manpower models are studied including Markov Chain and Renewal Models using grade and/or length of service categories. Statistical techniques to estimate relevant attrition and promotion rates from cohort and census data are also included in the course to provide both longitudinal and cross-sectional views of personnel systems. Career aspects are analyzed with respect to attrition, promotion opportunity and time to promotion in hierarchical systems with or without promotion zones. Examples emphasize the personnel systems of the military services. PREREQUISITES: OA 3201, OA 3301, OA 3103.

OA 4910 Selected Topics in Operations Analysis (2-0 to 5-0).
Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background of advanced work in operations research and departmental approval.

OA 4930 Readings in Operations Analysis (2-0 to 5-0).
This course may be repeated for credit if course content changes. PREREQUISITE: Departmental approval. *Graded on Pass/Fail basis only.*

SERVICE COURSES

OS 0810 Thesis Research for C3 Students (0-0).
Every student conducting thesis research will enroll in this course.

Upper Division Courses

OS 2101 Analysis of Experimental Data (4-0).
Introduction to statistical analysis of measurements and experimental data. Frequency distributions, graphical representations. Populations and sampling. Principle of least squares, estimation of mean and standard deviation. Curve fitting and regression, propagation of errors. Confidence intervals, tests and contingency tables. Elementary ANOVA. Relevant probabilistic concepts introduced as needed.

OS 2102 Introduction to Applied Probability for Electrical Engineering (4-1).
First course in probability. Structure of a probability model, density, distribution function, expectation and variance. Some basic models, Binomial, Poisson and Gaussian distributions. Conditional probability and indepencence. Joint distributions, covariance and central limit theorem. Transformations of random variables. PREREQUISITE: MA 1116 or equivalent.

OS 2103 Applied Probability for Systems Technology (4-1).
First course in probability for students in operational curricula. Topics include classical probability calculation, discrete and continuous random variables, basic probability distributions, introduction to modelling, expectation, variance, covariance and rudiments of discrete-time processes. Emphasis is on developing familiarity with basic concepts and computational skills rather than mathematical rigor. Problem session is used in part to refresh and reinforce necessary calculus topics. PREREQUISITE: MA 1116.

Upper Division or Graduate Courses

OS 3001 Operations Research for Computer Scientists (4-0).
An introduction to the methodology and techniques of operations research, with special emphasis on the computational aspects and on computer-related applications. Topics include linear programming, queueing theory, and PERT. Homework assignments include writing computer programs for some of the algorithms presented. PREREQUISITES: MA 2045, CS 0110, course in probability and statistics.

OS 3002 Operations Research for Intelligence (4-0).
This course provides an introduction to the approach and methods of operations research (OR), with special emphasis on military applications of interest to intelligence. It focuses on the mathematical modelling of combat operations and considers intelligence aspects (particularly Soviet use of OR). Students develop basic skills in such modelling. Topics include: operational definitions, measurement of combat effectiveness, different types of combat models, model validation/verification, and models versus modelling. Also included are modelling of processes of target acquisition, fire assessment (kill probabilities and target coverage), tactical-decision making, and integration of these submodels. Game-theoretic models of tactical decisions are emphasized and used as a vehicle for providing a framework for operational gaming.

OS 3003 Operations Research for Electronic Warfare (4-0).
This course deals with applications of quantitative models to operational electronic warfare problems, with the underlying idea being to make decisions by optimizing some measure of effectiveness (MOE). Topics covered include ESM, ECM/ECCM, strike warfare, ASMD, and cost-effectiveness tradeoffs. PREREQUISITES: Calculus and OS 2103.

OS 3004 Operations Research for Computer Systems Managers (5-0).
A one-quarter survey of operations research techniques of particular interest to students in computer systems management. Model formulation, decision theory, linear programming, project management techniques, inventory models, queueing and simulation, reliability and maintainability. Examples will illustrate the application of these techniques to the management of computer systems. PREREQUISITES: MA 2300, OS 3101.

OS 3005 Operations Research for Communications Managers (4-0).
A one-quarter survey of operations research techniques of particular interest to students in communications management. Model formulation, decision theory, games, linear programming, network flows, CPM and PERT, reliability and maintainability, queueing theory, and systems simulation. PREREQUISITES: MA 2300, OS 3101.

OS 3006 Operations Research for Management (4-0).
A survey of problem solving techniques for operations research. Topics include decision theory, linear programming, models, project scheduling, inventory, queueing and simulation. PREREQUISITES: MA 2300, OS 3101 or OS 3105.

OS 3007 Operations Research Methodology (4-0).
Survey of Operations Research techniques not covered in OS 3006. Topics may include simulation, search theory, extensions of combat models, network flows, and Markov chains. PREREQUISITES: OS 3106 and OS 3006 concurrently.

OS 3008 Analytical Planning Methodology (4-0).
A one-quarter survey of operations research techniques of particular interest to students in the C3 curriculum, with emphasis on model formulation. Topics include linear and nonlinear programming, integer programming, networks, flow shop and project scheduling, decision analysis, queueing and simulation. PREREQUISITE: MA 2300.

OS 3101 Statistical Analysis for Management (5-0).
A specialized course covering the basic tools of probability and statistics with emphasis on managerial applications using the hand-held calculator. The course is divided into three units covering basic probability, statistical inference, and regression analysis. Computations are relegated to the calculator through the use of prepared magnetic card programs so that emphasis is placed on selection of models and application of results. Topics in probability include standard distributions including binomial, Poisson and normal. Statistical inference is restricted to parametric tests and confidence intervals for a single random variable. Regression analysis covers both the simple linear model and multiple regression with two regressors; statistical inference including tests and confidence intervals for all regression parameters is included. PREREQUISITES: MA 1110 and MA 2300 or equivalents.

OS 3104 Statistics for Science and Engineering (4-0).
Acquaint the engineering student with the techniques of statistical data analysis with examples from quality control, life testing, reliability and sampling inspection. Histograms and empirical distributions and random variables are introduced along with their probability distributions and associated characteristics such as moments and percentiles. Following a brief introduction to decision making, standard tests of hypotheses and confidence intervals for both one and two parameter situations are treated. Regression analysis is related to least squares estimation and associated tests of hypotheses and confidence intervals treated. Additional techniques of data analysis using nonparametric procedures are developed. Quality control charts are discussed as applications along with sampling inspection by attributes and by variables. PREREQUISITE: Calculus.

OS 3105 Statistical Analysis for Management I (3-1).
The first of a two-quarter course in the use of the tools of probability and statistics oriented toward management applications. Skills in numerical computation are developed in laboratory periods through the use of MINITAB. Emphasis in the lectures is placed on modelling problems and interpreting results. Those aspects of probability structure that are germaine to statistical procedures are presented along with standard families of distributions such as the binomial and normal. Standard topics of statistical inference for one and two variables are introduced in the settings of both hypothesis testing and confidence interval estimation. PREREQUISITE: MA 2300.

OS 3106 Statistical Analysis for Management II (3-1).
The second of a two-quarter course in the use of the tools of probability and statistics oriented toward management applications. Using the tools and skills developed in OS 3105, the course consists of a general study of linear models. Analysis of variances for one and two way models is followed by simple linear and multiple regression including such topics as curve fitting, residual analysis, and stepwise regression, along with correlation analysis. Again the computer is used as a tool to facilitate computations with emphasis on statistical packages for large data bases, such as SPSS and SAS. The course concludes with a sampling of nonparametric procedures. PREREQUISITE: OS 3105.

OS 3301 Systems Effectiveness Concepts and Methods (4-0).
An introduction to system reliability, maintainability, and effectiveness analysis. Failure (repair) rates and mean times to failure (repair). Models for aging and completion. Block diagrams and fault trees. Life testing. Availability, interval reliability, and the synthesis of reliability, maintainability, and effectiveness analysis. PREREQUISITES: OS 3105, OS 3106.

OS 3303 Computer Simulation (4-1).
Design, implementation and use of digital simulation models will be covered with special emphasis on features common to ASW problems. War gaming will be discussed and a game using the digital computer will be played and critiqued by the class. Exercise planning and analysis will be treated. Basic

topics are explained including computer generation of random variates, statistical design and monitoring of model progress, machine representation of dynamic data structures, model verification and validation on special purpose simulation and gaming languages. PREREQUISITES: OS 2103, OS 3604 or equivalent, and a working knowledge of FORTRAN programming.

OS 3401 Human Factors Engineering (3-0).
An introduction to human factors engineering for students in fields such as engineering. Designed to give the student an appreciation of man's capacities and limitations and how these can affect the optimum design of the man-machines system. Emphasis on integration of human factors into the system development cycle considering such topics as manpower/personnel costs, control and display design, human energy expenditure, physiological costs, and evaluation systems. PREREQUISITE: A previous course in probability and statistics.

OS 3402 Human Vigilance Performance (3-1).
Course involves an examination of man's attentiveness and capability in the detection of changes in stimulus events over prolonged periods of observation. Topics to be covered include theories of vigilance; task, signal, subject and environmental influences on performance; physiological and psychological responses and vigilance performance measurement. This course is designed for the ASW curriculum. PREREQUISITE: None.

OS 3403 Human Factors in EW (3-1).
This course will provide the student with the ability to evaluate and predict human performance in specified operational environments. The effects of stress factors such as noise, temperature, motion, workload, etc., on various aspects of human performance will be studied. Students will identify the control and display requirements or an EW system and design a workspace to accommodate an EW data reduction/analysis system. PREREQUISITE: OS 3604.

OS 3404 Man-Machine Interaction (3-0).
An introduction to the man-machine interface problems in C3. Information, display and human communication requirements for effective C3. Applied orientation with student receiving his own computerized mailbox on the ARPANET enabling him to experience message handling systems, query languages, computer to computer communications between the U.S. and Europe, command and control applications programs, file transfer between host computers, etc. PREREQUISITES: Enrollment in C3.

OS 3601 Search, Detection, and Localization Models (4-0).
An introduction to the decision problems associated with Navy detection systems. The relation of detection models to search and localization models, measures of effectiveness of search/detection systems, and the optimum allocation of search effort are discussed. This course is designed for the ASW curriculum. PREREQUISITES: OS 2103 and SECRET clearance.

OS 3602 Introduction to Combat Models and Weapons Effectiveness (4-1).
This course deals with the application of quantitative models to military problems. Topics include Lanchester's theory, game theory, reliability theory, systems effectiveness, and war gaming. This course is designed for the ASW curriculum. PREREQUISITES: OS 2103 and MA 2129.

OS 3603 Simulation and War Gaming (3-1).
Design, implementation and use of digital simulation models will be covered with special emphasis on features common to C3 and EW problems. War gaming will be discussed and a game using the digital computer will be played and critiqued by the class. Exercise planning and analysis will be treated. Basic topics are explained including computer generation of random variates, statistical design and monitoring of model progress, machine representation of dynamic data structures, model verification and validation on special purpose simulation and gaming languages. PREREQUISITES: OS 2103, OS 3604 or equivalent, and a working knowledge of FORTRAN programming. SECRET clearance required.

OS 3604 Decision and Data Analysis (4-0).
This course provides an introduction to the techniques of decision analysis, statistics and data analysis. It is primarily for students in the ASW, EW and C3 curricula. Emphasis is placed on the analysis of data and decision making in the ASW, EW and C3 environments. PREREQUISITES: OS 2103 or equivalent.

OS 3636 Architecture of CCC Information Systems (4-0).
This course is intended for students in the command and control program. It provides an introduction to the evaluation and modelling of command-control-communications-and intelligence (C3I) systems, with an emphasis on the comparative anatomy of Blue and Red systems and operational intelligence. The student is introduced to concepts pertaining to the design, functioning, and evaluation of such large-scale systems and their architecture. PREREQUISITE: Enrollment in CCC program.

OS 3702 Manpower Requirements Determination (4-0).
The objective is to enable the student to use some of the tools of industrial engineering in the determination of the quantity and quality of manpower required in military systems. Techniques include motion and time study, work sampling, predetermined time standards, work design and layout, materials handling, procedures review and process design. Applications for ship and squadron manning documents and SHORESTAMPS are included. PREREQUISITES: OS 3006 or OA 3201 and OA 3301.

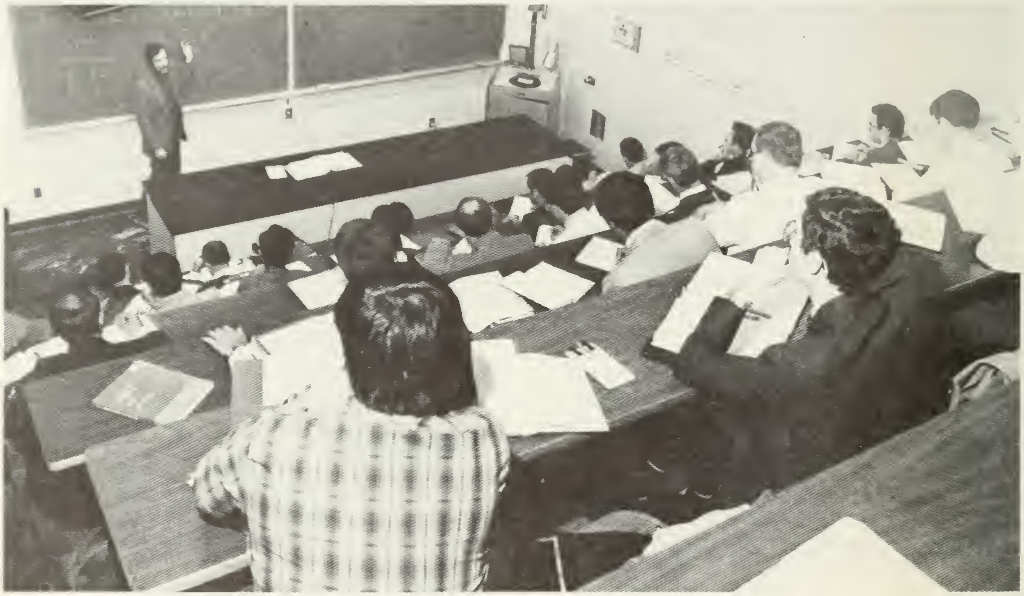
Graduate Courses

OS 4601 Test and Evaluation (4-0).
Designed for system technology students, this course examines problems associated with tests and evaluations of weapon systems and tactics. Included are concepts from experimental design, regression analysis, life testing, data analysis. Realistic data sets and examples are discussed and analyzed. PREREQUISITE: Inferential statistics.

OS 4602 C3 Systems Evaluation (3-3).
The course is designed for systems technology students in the Command, Control and Communications curriculum. The course deals with techniques for the design, implementation and analysis of experiments or exercises aimed at the test and evaluation of systems, tactics, or operational concepts and policies. Course topics include modeling, experimentation methodology, design of experiments, multi-criteria decision analysis, reliability, and man-machine interaction. Case studies and real data will be examined. Students will actively participate in evaluations through laboratory experiments. PREREQUISITES: OS 3008, OS 3603, OS 3604, SECRET NOFORN clearance.

OS 4701 Manpower and Personnel Models (4-0).
The objective of this course is to introduce the student to the major types of manpower and personnel models for estimating the effects of policy changes on the personnel system. Topics include longitudinal and cross-section models, optimization models, data requirements and validation. Applications in the form of current military models are included. PREREQUISITES: OS 3006 and OS 3106.

DEPARTMENT OF PHYSICS



Gordon Everett Schacher, Professor of Physics; Chairman (1964)*; A.B., Reed College, 1956; Ph.D., Rutgers, 1961.

Robert Louis Armstead, Associate Professor of Physics (1964); B.S., Univ. of Rochester, 1958; Ph.D., Univ. of California at Berkeley, 1964.

Anthony A. Atchley, Assistant Professor of Physics (1985); B.A., Univ. of the South, 1979; M.S., New Mexico Institute of Mining and Technology, 1982; Ph.D., University of Mississippi, 1985.

Steven Richard Baker, Adjunct Professor of Physics (1985); B.S., Univ. of California at Los Angeles, 1975; M.S., 1977; Ph.D., 1985.

Fred Ramon Buskirk, Professor of Physics (1960); B.S., Western Reserve Univ., 1951; Ph.D., Case Institute of Technology, 1958.

Alfred William Madison Cooper, Professor of Physics (1957); B.A., Univ. of Dublin, 1955; M.A., 1959; Ph.D., The Queen's Univ. of Belfast, 1961.

Alan Berchard Coppens, Associate Professor of Physics (1964); B. Eng. Phys., Cornell Univ., 1959; M.S., Brown Univ., 1962; Ph.D., 1965.

Harvey Arnold Dahl, Assistant Professor of Physics (1964); B.S., Stanford Univ., 1951; Ph.D., 1963.

Kathryn Conway Dimiduk, Assistant Professor of Physics (1983); B.A., Cornell University, 1979; M.S., Stanford University, 1981; Ph.D., 1983.

John Norvell Dyer, Distinguished Professor of Physics (1961); B.A., Univ. of California at Berkeley, 1956; Ph.D., 1960.

Steven Lurie Garrett, Assistant Professor of Physics (1982); B.S., Univ. of California at Los Angeles, 1970; M.S., 1972; Ph.D., 1977.

Nathaniel Elliot Glass, Adjunct Professor of Physics (1984); B.A., Univ. of Pennsylvania, 1970; Ph.D., State Univ. of New York at Stony Brook, 1976.

Suntharalingam Gnanalingam, Adjunct Professor of Physics (1985); B.Sc., Univ. of Ceylon, 1945; M.A., Cambridge University, 1951; Ph.D., 1954.

Harry Elias Handler, Professor of Physics (1958); B.A., Univ. of California at Los Angeles, 1949; M.A., 1951; Ph.D., 1955.

Don Edward Harrison, Jr., Professor of Physics (1961); B.S., College of William and Mary, 1949; M.S., Yale Univ., 1950; Ph.D., 1953.

Otto Heinz, Professor of Physics (1962); B.A., Univ. of California at Berkeley, 1948; Ph.D., 1954.

Edmund Alexander Milne, Associate Professor of Physics (1954); B.A., Oregon State College, 1949; M.S., California Institute of Technology, 1950; Ph.D., 1953.

John Robert Neighbours, Professor of Physics (1959); B.S., Case Institute of Technology, 1949; M.S., 1951; Ph.D., 1953.

Steven Francis Nerney, Associate Professor of Physics (1985); B.A., California State Univ. at San Francisco, 1966; M.S., 1968; Ph.D., University of Colorado, 1974.

Gregory Bertman Netzorg, Instructor in Physics (1984); B.S., Oregon State Univ., 1970; M.S., Naval Postgraduate School, 1977.

Rudolph Henry Nichols, Jr., Adjunct Professor of Physics (Underwater Physics Chair) (1984); B.A., Hope College, 1932; M.A., Univ. of Michigan, 1933; Ph.D., 1939.

James Vincent Sanders, Associate Professor of Physics (1961); B.S., Kent State Univ., 1954; Ph.D., Cornell Univ., 1961.

Fred Richard Schwirzke, Professor of Physics (1967); B.S., Univ. of Rostock, 1950; M.S., Univ. of Karlsruhe, 1953; Ph.D., 1959.

Donald Lee Walters, Associate Professor of Physics (1983); B.S., Kansas State University, 1966; Ph.D., 1971.

Oscar Bryan Wilson, Jr., Professor of Physics (1957); B.S., Univ. of Texas, 1944; M.A., Univ. of California at Los Angeles, 1948; Ph.D., 1951.

Karlheinz Edgar Woehler, Professor of Physics (1962); B.S., Univ. of Bonn, 1953; M.S., Technical Univ., Aachen, 1955; Ph.D., Univ. of Munich, 1962.

William Bardwell Zeleny, Associate Professor of Physics (1962); B.S., Univ. of Maryland, 1956; M.S., Syracuse Univ., 1958; Ph.D., 1960.

Emeritus Faculty

John Niessink Cooper, Professor Emeritus (1956); B.A., Kalamazoo College, 1935; Ph.D., Cornell Univ., 1940.

Eugene Casson Crittenden, Jr., Distinguished Professor Emeritus (1953); B.A., Cornell Univ., 1934; Ph.D., 1938.

Sydney Hobart Kalmbach, Professor Emeritus (1947); B.S., Marquette Univ., 1934; M.S., 1937.

Raymond Leroy Kelly, Professor Emeritus (1960); B.A., Univ. of Wichita, 1947; M.S., Univ. of Wisconsin, 1949; Ph.D., 1951.

Gilbert Ford Kinney, Distinguished Professor Emeritus (1942); A.B., Arkansas College, 1928; M.S., Univ. of Tennessee, 1930; Ph.D., New York Univ., 1935.

Herman Medwin, Professor Emeritus (1955); B.S., Worcester Polytechnic Institute, 1941; M.S., Univ. of California at Los Angeles, 1948; Ph.D., 1953.

Richard Alan Reinhardt, Professor Emeritus (1954); B.S., Univ. of California at Berkeley, 1943; Ph.D., 1947.

George Wayne Rodeback, Associate Professor Emeritus (1960); B.S., Univ. of Idaho, 1943; M.S., Univ. of Illinois, 1947; Ph.D., 1951.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEGREE REQUIREMENTS

The Department of Physics offers the MS degree in Physics and in Engineering Science. In addition, the Ph.D. is offered by the Department. Upon approval by the Department, courses taken at other institutions may be applied towards satisfying degree requirements.

MASTER OF SCIENCE IN PHYSICS

1. A candidate for the degree Master of Science in Physics must complete satisfactorily a program of study which includes a minimum of 30 quarter hours of physics courses (not including thesis) distributed among courses at the graduate level; of this 30 hours at least 15 hours must be at the 4000 level. Upon approval of the Chairman of the Physics Department a maximum of 4 hours of courses taken in another department may be applied toward satisfying the above requirements. In lieu of the preceding requirement, students who are qualified to pursue graduate courses in physics when they arrive at the Postgraduate School may complete a minimum of 20 hours entirely of 4000 level physics courses. In addition, all students must present an acceptable thesis.

2. The following specific course requirements must be successfully completed for a student to earn the degree of Master of Science in Physics:
   a. Thermodynamics and Statistical Mechanics — the student must take a two-quarter sequence or present equivalent preparation in this area.
   b. A course in Advanced Mechanics or Quantum Mechanics.
   c. A course in Electromagnetism at the 4000 level.
   d. An advanced course in Modern Physics.
   e. Specialization, to include at least two advanced courses in an area of specialization.

3. Programs leading to the Master of Science degree in Physics must be approved by the Chairman of the Department of Physics.

MASTER OF SCIENCE IN ENGINEERING SCIENCE

Students of the Weapon Systems Engineering Curriculum (530) who elect a Physics area as their specialization option will receive the degree Master of Science in Engineering Science. The program must include at least 36 credit hours of graduate work in engineering, science and mathematics, at least 12 of which must be at the 4000 level. Of these 36 hours, at least 20 hours, including work at the 4000 level, must be in the Department of Physics. This will be the major department, and cognizance over the specialization course sequences, thesis research areas and the degree resides with the Chairman of the Department of Physics.

In addition to the major, the program must contain at least 12 hours at the graduate level in courses representing areas other than the major.

The candidate must present an acceptable thesis on a topic given prior approval by the Department of Physics. Final approval of the program leading to the Master of Science in Engineering Science with major in Physics shall be obtained from the Chairman of the Department of Physics.

DOCTOR OF PHILOSOPHY

The Ph.D. degree is offered in the Department in several areas of specialization which currently include Acoustics, Atomic Physics, Solid State Physics, Theoretical Physics, Nuclear Physics and Plasma Physics.

Requirements for the degree may be grouped into 3 categories: courses, thesis research and examinations in major and minor fields.

The required examinations are outlined under the general school requirements for the Doctor's degree. In addition to the school requirements, the Department requires a preliminary examination to show evidence of acceptability as a doctoral student.

The usual courses to be taken by the candidate include Classical Electrodynamics, Quantum Mechanics and Statistical Physics. (PH 4371, 4971, 4972, 4973, 4571, 4572). Suitable electives are to be chosen in physics and the minor fields, mainly from the list of graduate level courses.

PHYSICS LABORATORIES

The physics laboratories are equipped to carry on instructional and research work in atomic physics, nuclear physics, solid state physics, electro-optics, plasma physics, spectroscopy, and acoustics.

A 100-MeV electron linear accelera- with 5-microamp beam current is used in radiation studies.

The electro-optics laboratory uses imaging and detecting systems from the far infrared to the visible range including instrumentation for seagoing experiments in optical propagation. The laser laboratory contains a giant pulse laser and associated detection equipment for the visible spectrum as well as a high power laser in the IR region.

The plasma physics laboratory includes a plasma system, diagnostic equipment for studies of plasma dynamics, and a steady state plasma source with magnetic fields to 10,000 gauss.

The spectroscopy equipment includes a large grating spectrograph, a large prism spectrograph, and an infrared spectrophotometer. The spectroscopic data center contains a comprehensive compilation of the known energy levels and atomic spectral lines in the vacuum ultraviolet range.

The acoustics laboratory equipment includes a large anechoic chamber, a small reverberation chamber, and a multiple-unit acoustics laboratory for student experimentation in airborne acoustics. Sonar equipment, test and wave tanks, and instrumentation for investigation in underwater sound comprise the underwater acoustics laboratory.

DEPARTMENTAL COURSE OFFERINGS

PHYSICS

PH 0110 Refresher Physics (5-3).
NON-CREDIT. A six-week refresher course of selected topics from elementary mechanics for incoming students. Typical topics are kinematics, Newton's Laws, the concepts of work, energy, and linear momentum, and simple harmonic motion. Vector algebra and some aspects of calculus are developed as needed and their use is emphasized. The two ninety-minute laboratory periods are devoted to guided problem solving. PREREQUISITES: Previous college courses in elementary physics and integral calculus.

PH 0499 Acoustics Colloquium (0-1).
Reports on current research, and study of recent research literature in conjunction with the student thesis. PREREQUISITE: A course in acoustics.

PH 0810 Thesis Research (0-0).
Every student conducting thesis research will enroll in this course.

PH 0999 Physics Colloquium (0-1).
Discussion of topics of current interest by NPS and outside guest speakers.

Lower Division Courses

The sequence of courses PH 1021, PH 1022, PH 2023 and PH 2024 represent a thorough review of the basic principles and concepts of classical physics combined with an introduction to the statistical techniques of data analysis. These courses are primarily intended for students in the WS, WT, and WN curricula.

PH 1021 Basic Physics I: Mechanics (4-2).
Vector algebra, particle kinematics in one and two dimensions, Newton's Laws of Motion, particle dynamics, work, kinetic and potential energy, conservation of energy, linear momentum and its conservation laws, collisions, rotational kinematics and dynamics, equilibrium of rigid bodies, oscillations and gravitation. PREREQUISITE: A course in calculus (may be taken concurrently).

PH 1022 Basic Physics II: Electricity and Magnetism (4-2).
Electric Charge, Coulomb's Law, electric field and potential, Gauss' Law, capacitors and dielectrics, current and resistance, EMF and simple circuits, magnetic field, Ampere's Law, Faraday's Law, inductance, electromagnetic oscillations and waves, Maxwell's equations. PREREQUISITE: PH 1021 or equivalent.

The sequence of introductory physics courses 1081, 1082, 1083 is intended for students with little or no background in mathematics or physics. Emphasis is therefore placed on the development of problem solving skills. These courses are generally given on a six week accelerated schedule, and are normally given on a pass fail basis.

PH 1081 Introductory Physics I: Mechanics (3-2).
Vectors, Kinematics in one and two dimensions, Newton's Laws, Force Laws, Work and Energy, Conservative Forces, Conservation of Energy, Linear Momentum. PREREQUISITES: A course in calculus (may be taken concurrently).

PH 1082 Introductory Physics II: Thermodynamics and Wave Motion (3-2).
Fluids, Waves in Elastic Media, Sound Waves, Heat and the First Law of Thermodynamics, Kinetic Theory of Gases, Entropy and the Second Law of Thermodynamics. PREREQUISITES: PH 1081 and a course in calculus.

PH 1083 Introductory Physics III: Electricity & Magnetism (3-2).
Charge and Coulomb's Law, Electric Field, Gauss' Law, Electric Potential, Current & Resistance, Electromotive Force, Magnetic Field, Ampere's Laws, Faraday's Law. PREREQUISITES: PH 1081 and a course in calculus.

Upper Division Courses

PH 2023 Basic Physics III: Optics and Data Analysis (4-2).
Nature and Propagation of Light, Reflection and Refraction at interfaces, interference, diffraction, optical spectra, polarization. Discrete and continuous frequency distributions, propagation of errors, probability concepts, joint probability distributions, Monte Carlo experiments, estimation, hypothesis testing, introduction to random processes. PREREQUISITES: PH 1022 and a course in differential equations.

PH 2024 Basic Physics IV: Thermodynamics, Fluids and Acoustics (4-2).
Temperature Concept, Heat and the First Law of Thermodynamics, Kinetic Theory of Gases, Entropy and the Second Law of Thermodynamics, Fluid Statics, Fluid dynamics, Drag Waves in Elastic Media, Sound Waves, Speed and absorption of sound in the ocean, refraction of sound waves, detection theory and thresholds, active and passive sonar. PREREQUISITES: PH 1021 and a course in differential equations.

PH 2111 Introduction to Space Science (4-0).
A semiquantitive introduction to space science: Solar structure and emmissions, Geomagnetic Field, Radiation Belts, Upper Atmosphere, Ionosphere, The effects of man in the space environment. PREREQUISITES: A course in general physics and a course in ordinary differential equations (may be taken simultaneously).

PH 2119 Oscillation and Waves (3-2).
An introductory course designed to present mechanics to students studying acoustics. Kinematics, dynamics, and work and energy consideration for the free, damped, and driven oscillators. The wave equation for transverse vibration of a string, ideal and realistic boundary conditions, and normal modes. Longitudinal waves in bars. Transverse waves on rectangular and circular membranes. Vibrations of plates. Laboratory periods include problem sessions and experiments on introduction to experimental techniques and the handling of data; the simple harmonic oscillator analog; transverse waves on a string; and transverse, longitudinal, and torsional waves on a bar. PREREQUISITE: Courses in differential equations and basic physics.

PH 2123 Basic Physics: Waves and Optics (4-0).
A course to provide physical background to wave motion, acoustics, and optics for students in the Electronic Warfare curriculum, and to provide applications of analytical techniques to physical problems. Areas covered are harmonic motion - differential equations, complex notation, damped vibration and resonance; wave motion — properties of waves, sound waves, electromagnetic waves, light waves; optics — geometrical and wave optics. PREREQUISITES: MA 1112, MA 2129 and MA 2181 taken concurrently.

PH 2124 Basic Physics: Electromagnetism (2-0).
This course follows PH 2123. Basic concepts of electric and magnetic fields are introduced and their interaction with charges and currents discussed. The experimental laws are used to develop Maxwell's Equations, and simple solutions to these equations are considered. PREREQUISITES: PH 2123 or equivalent, and mathematics through vector analysis and ordinary differential equations.

PH 2151 Mechanics I — Particle Mechanics (4-1).
After a review of the fundamental concepts of kinematics and dynamics, this course concentrates on those two areas of dynamics of simple bodies which are most relevant to applications in Weapon Systems Engineering: vibrations and projectile motion. Topics include: damped and driven oscillations, rotating coordinate systems, projectile motion with atmospheric friction, and satellite orbits. PREREQUISITE: PH 1041 or equivalent; MA 2121 or equivalent course in ordinary differential equations (may be concurrent).

PH 2241 Modern Physics for Engineers (4-0).
An introductory course intended to impart a broad background in modern physics. The couse begins with a brief review of classical mechanics and electromagnetism, followed by atomic and molecular structure and spectra. Black body radiation, photoelectric effect, emission and absorption of radiation by atoms and molecules, and the energy band architecture of solids lead to an introduction to applications in lasers, semiconductors, and microwave devices. Applications may be tailored to suit the interests of the instructor and the class. PREREQUISITE: Elementary calculus and a course in basic physics, or consent of the Instructor.

PH 2251 Physical Optics and Introductory Modern Physics (4-2).
A course designed to provide the fundamental ideas of wave theory, physical optics, and introductory modern physics. Topics covered include the wave equation, phase and group velocity, Fourier transforms, interference, diffraction, polarization, birefringence, black-body radiation, special theory of relativity, the photon, photoelectric effect and Compton scattering. Bohr atom, de Broglie hypothesis, Schroedinger equation, infinite square well. A laboratory is included. PREREQUISITES: PH 1041, MA 2121 or equivalent.
(May be taken through Continuing Education as mini-courses PH 2253-55.)

PH 2265 Geometrical Optics (2-2).
The course first introduces geometrical optics; reflection and refraction of rays at plane and spherical surfaces; mirrors, plane and spherical; lenses, thick lenses and lens aberration; matrix methods for thick lenses and lens systems. A laboratory is included. Subjects to be covered include laboratory procedures, definition of measurement, random

and systematic errors, propagation of uncertainties, graphical and analytical treatment of data, statistical concepts, focal length of lens and mirror, refractive index of glass, thick lens, optical instruments, optical spectra, and prism spectrometer. PREREQUISITE: A course in basic physics.

PH 2270 Fundamentals of Electro-Optics (4-0).
This course is designed to provide the background knowledge for electro-optics to students in interdisciplinary curricula. Topics discussed include: matrix formulation of optics, catoptric and catadioptric systems, diffraction, behavior of gaussian profile beams, Fourier optics and resolution, atmospheric transmission, atomic and molecular energy states, line shapes, band theory of semiconductors, the p-n junction, light emitting diodes, stimulated emission, and lasers. PREREQUISITES: MA 3139 and PH 2124 (or equivalent).

PH 2351 Electromagnetism (4-1).
Electrostatic fields, Coulomb's law, potential, capacitance, field due to electric dipole and dielectric media. Magnetostatic fields, magnetic fields from current carrying wire, solenoid, and the magnetic dipole. The vector potential. Simple treatment of the magnetic field from a submarine. Faraday's law of induction and the coupling of electric and magnetic fields. Lorentz force on a moving charge. Maxwell's equations. PREREQUISITES: Basic electromagnetism (PH 1041 or equivalent), vector calculus (MA 2047 or equivalent).

PH 2471 Introduction to the Sonar Equations (3-0).
A discussion of each term of the sonar equations, with application to the detection, localization, and classification of underwater vehicles. Topics include ray acoustics, simple transmission loss models, tonals, spectrum and band levels, directivity index, array gain, doppler shift, and detection threshold. This course is intended primarily for students in the Antisubmarine Warfare curriculum. PREREQUISITE: Precalculus mathematics. *(May be taken through Continuing Education as mini-courses PH 2474-76).*

PH 2551 Thermodynamics (4-0).
This course in thermodynamics has an engineering physics flavor, covering theoretical foundations and practical applications. Topics include: Energy and the First Law; Properties and state description of thermodynamic systems; Entropy and the Second Law; Consequences of the Second Law; Reversible and irreversible processes; Thermodynamic functions; Characteristics of energy conversion systems; Thermodynamics of non-reacting and reacting mixtures; Introduction to statistical thermodynamics and molecular kinetics; Introduction to irreversible thermodynamics. PREREQUISITES: PH 2151 and PH 2251 (the latter may be taken concurrently).

PH 2810 Survey of Nuclear Physics (4-0).
An introduction to the basic concepts of nuclear physics with emphasis on neutron physics and nuclear reactors. Atomic nature of matter, wave-particle duality, energy levels. Basic nuclear properties, radioactivity, neutron reactions. Elements of fission and fusion reactors.

Upper Division or Graduate Courses

PH 3001 Simulation of Physical Systems (3-1).
Comparisons between simulation, theory and experimentation as techniques of scientific investigation. Computer simulation methodology and techniques: Monte Carlo and deterministic simulations, stochastic techniques, design of simulations, variance reduction and analysis of results. Applications from physics and/or weapons performance. There is a one-hour applications laboratory. PREREQUISITES: MA 3400, or OS 3602, or consent of instructor.

PH 3112 Orbital Mechanics (4-0).
Review of basic concepts of newtonian mechanics. Solution of equations of motion for inverse square force law. Geometric and energy relations for simple orbits, Orbit determinations from observations, Basic orbital maneuvers, Ground tracks and earth coverage. Orbital perturbations. PREREQUISITES: A course in basic mechanics and a course in ordinary differential equations.

PH 3152 Mechanics II — Extended Systems (4-1).
The principles of dynamics are applied to real extended bodies. Topics include: principles of rocket propulsion, rotational motion of axisymmetric bodies and its application to projectile spin and gyroscopic motion. An introduction to generalized methods of description of dynamic systems is given and the general behavior of complex vibrating systems is studied. PREREQUISITE: PH 2151.

PH 3161 Fluid Dynamics (4-1).
This course emphasizes the dynamics of real compressible fluids. The basic properties of fluids are introduced and the concepts of fluid kinematics, stress, and strain are discussed. Both the control-volume and differential-equation approaches are applied to the flow of a viscous fluid. The laws of similarity are developed, and the significance of Reynolds, Froude, and Mach number discussed. Topics covered include laminar and turbulent flow, isentropic subsonic channel flow, supersonic flow in nozzels, and two-dimensional supersonic flow. PREREQUISITE: PH 2151 or equivalent.

PH 3166 Physics of Underwater Vehicles (4-2).
This course emphasizes the dynamics of real incompressible fluids. The basic properties of fluids are introduced and the concepts of fluid kinematics, stress, and strain are discussed. Both the control-volume and the differential-equation approaches are applied to the flow of a viscous fluid. The laws of similarity are developed, and the significance of Reynolds, Froude, and Mach numbers are discussed. Topics covered include laminar flow, turbulent flow, boundary layer theory, and the calculation of lift and drag. One or more special topics may be discussed (surface waves, cavitation, and the fluid-dynamic generation of sound) depending upon the interests of the instructor and students. PREREQUISITE: PH 2151 or equivalent.

PH 3190 Methods of Theoretical Physics (4-0).
The general methods of theoretical physics are applied to specific problems chosen from: classical waves, scattering, classical electrodynamics, resonant cavities, incompressible flow, dielectric and magnetic media, heat conduction, quantum mechanics, and Fourier optics. Emphasis is on the physical applications. PREREQUISITES: MA 2121 and a sequence of courses in basic physics.

PH 3271 Electro-Optic Principles and Devices (4-0).
This course is designed to provide students in interdisciplinary programs with an understanding of the principles and capabilities of the component devices comprising military electro-optic and infrared systems. Topics treated include: atmospheric extinction, turbulence effects on optical transmission and imaging, thermal blooming and breakdown, adaptive optics, thermal radiation, target signatures, backgrounds, modulators and shutters, beam steerers, reticles, detector characteristics and types, detector noise and cooling, imaging detectors for intensifiers, television and FLIR, CCD and CID devices, and displays. PREREQUISITES: PH 2270 or equivalent.

PH 3281 Non-Acoustic Sensor Systems (4-0).
This course covers the physical principles underlying the operation of a number of operational and proposed non-acoustic sensor systems. Geomagnetism, magnetometers and gradiometers, MAD signatures, optical and IR transmission in the atmosphere and in sea water. FLIR and radar systems for ASW. Exotic detection schemes. PREREQUISITES: PH 3366, EE 3714, SECRET clearance.

PH 3321 Radiating Systems (4-0).
This course for students of Operations Research and other Weapon System oriented non-engineering curricula discusses the physical principles exploited by information gathering systems with emphasis on general capabilities and limitations. After a general introduction to wave propagation, topics of discussion are electromagnetic waves, radar, electro-optics including lasers, and underwater sound. These topics will be applied to specific systems such as missile guidance, sonobouys, and phased arrays, as appropriate to the class and instructor. PREREQUISITES: MA 1116 or equivalent may be taken concurrently, or by consent of Instructor.

PH 3352 Electromagnetic Waves (4-0).
Plane waves in vacuum and dielectrics, boundary conditions, energy density and Poynting theorem. Polarization, reflection and refraction at dielectric boundaries and conducting surfaces for normal and oblique incidence. Electromagnetic propagation in conductors, with emphasis on sea water, metals and the ionosphere. Waveguides. Radiation from a dipole antenna, qualitative treatment of antenna arrays and antenna patterns. PREREQUISITE: PH 2351.

PH 3360 Electromagnetic Wave Propagation (4-1).
An analytic introduction to electromagnetic field theory is presented, with examples from electrostatics, magnetostatics and induction, emphasizing the development of Maxwell's equations. The Maxwell equations are used to develop wave propagation in a vacuum, dielectrics and conductors, reflection and refraction. Guided waves, radiation from a dipole and waves in the ionosphere are treated. PREREQUISITES: MA 2047, MA 3132, PH 1041 and PH 2151.

PH 3366 Electromagnetic Wave Propagation (4-0).
This course is designed for the ASW curriculum and may be taught as an accelerated 6-week course. An introduction to Maxwell's equations and the basic properties of electromagnetic wave propagation in various media and the interface between media. These concepts are applied to wave propagation in the sea, the atmosphere and the ionosphere. Basic properties of antennas and waveguides. PREREQUISITES: A basic course in electricity and magnetism, vectors, and differential equations.

PH 3421 Acoustic Wave Propagation (4-1).
Development of and solutions to the acoustic wave equation in extended media. Propagation of plane waves in fluids and reflection and transmission at plane boundaries. Steady state response of acoustic cavities and propagation in waveguides. Sound absorption and dispersion for classical fluids. The eikonal equation and necessary conditions for ray acoustics; refraction and ray diagrams. Method of images. Mode propagation in shallow water channels. Laboratory experiments on selected topics. PREREQUISITES: A course in basic mechanics and a course in differential equations.

PH 3431 Physics of Sound in the Ocean (4-2).
A survey of physical acoustics with emphasis on the generation, propagation, and detection of sound in the ocean. Topics include: the acoustic wave equation and its limitation in fluids; solutions for plane and diverging waves; ray acoustics; radiation of sound; reflection from boundaries; normal mode propagation in the ocean; effects of inhomogeneities and sound absorption; term by term analysis of the sonar equations emphasizing transmission loss models and detection threshold models; properties of transducers for underwater sound. Laboratory experiments include surface interference, spectral analysis of noise, normal modes, waveguides, and acoustical sources. PREREQUISITES: A course in general physics, a course in differential equations, and working knowledge of complex exponential notation.

PH 3451 Fundamental Acoustics (4-2).
Development of, and solutions to, the acoustic wave equation in fluids. Propagation of plane, spherical and cylindrical waves in fluids, sound pressure level, intensity, and specific acoustic impedance. Normal- and oblique-incidence reflection and transmission from plane boundaries. Transmission through a layer. Image theory and surface interference. Sound absorption and dispersion for classical and relaxing fluids. Acoustic behavior of sources and arrays, continuous line source, plane circular piston, radiation impedance, and the steered line array. Transducer properties, sensitivities, and calibration. Laboratory experiments include longitudinal waves in an air-filled tube, surface interference, properties of underwater transducers, three-element array, reciprocity calibration, speed of sound in water, and absorption in gases. PREREQUISITES: PH 2119.

PH 3452 Underwater Acoustics (4-1).
This course is a continuation of PH 3451. Lumped acoustic elements and the resonant bubble. Normal modes in rectangular, cylindrical and spherical enclosures. Steady-state response of acoustic waveguides of constant cross section, propagating and evanescent modes, and group and phase speeds. Transmission of sound in the ocean, the eikonal equation and necessary conditions for ray theory, and refraction and ray diagrams. Sound propagation in the mixed layer, the convergence zone, and the deep sound channel. Passive sonar equation, ambient noise, and doppler effect and bandwidth considerations. Active sonar equations, target strength and reverberation. Laboratory experiments include Helmholtz resonators, normal modes in cylindrical enclosures, water-filled wavequide, and noise analysis. PREREQUISITE: PH 3451.

PH 3458 Noise, Shock and Vibration Control (4-0).
The application of the principles of acoustics and mechanics to the problems of controlling noise, vibration and mechanical shock. Topics include: Linear mechanical vibrations; introduction to vibrations of non-linear systems; damping mechanisms; vibration and shock isolation; noise generation

and control; effects of noise on man; application to problems of Naval interest such as ship quieting and industrial noise control. PREREQUISITE: A course in acoustics.

PH 3461 Explosives and Explosions (4-1).
Explosives terminology; manufacturing and testing of high explosives and propellants; flame temperatures; thermochemistry of explosive decompositon; the detonation state; explosives safety. Generation and propagation of explosive shock waves in air; Rankine-Hugoniot equations; scaling laws; normal, oblique, and Mach reflection. Dynamic blast loads and corresponding structure response. PREREQUISITE: PH 2551 or equivalent.

PH 3463 Special Topics in Underwater Acoustics and Sound (3-2).
Special topics of interest in the areas of underwater sound, transduction, propagation and detection, depending on the interests and needs of the students. PREREQUISITE: PH 3431 or PH 3452 or PH 3472.

PH 3472 Underwater Acoustics (4-2).
The third of a four-course sequence in acoustics for students in the ASW curriculum, this course is an analytical study of those aspects of underwater sound that influence the sonar equations. Topics include: The wave equation in fluids; acoustic properties of fluids; plane, spherical, and cylindrical waves; simple sources; transducer properties and sensitivities; surface interference; the three-element array; normal-and oblique-incidence reflection and transmission at boundaries; image theory and the shallow-water channel; continuous line source and the plane circular piston; radiation impedance; linear arrays with steering. Laboratory experiments include advanced acoustic instrumentation, longitudinal waves in an air-filled tube, surface interference, properties of underwater transducers, and the 3-element array. PREREQUISITES: PH 2471.

PH 3561 Introductory Statistical Physics (4-0).
Distribution functions, kinetic theory, transport processes, introduction to classical and quantum distributions. Applications to gases, solids, and radiation. PREREQUISITE: PH 3651.

PH 3600 Weapons Systems and Weapons Effects (4-0).
This course will cover technical aspects of three areas of modern weapons systems: Nuclear weapons and effects on personnel, equipment and structures; Principles of directed energy weapon concepts and their interactions with targets; Space based defense system concepts. PREREQUISITE: PH 3321 or equivalent.

PH 3651 Atomic Physics (4-2).
The Schroedinger equation, harmonic oscillator, and the hydrogen atom. Electron spin. The exclusion principle and the periodic table. Multi-electron atoms, the vector model, and coupling schemes. Zeeman effect. Black body radiation, Einstein coefficients, transitions, and lasers. Band theory of solids. Semiconductors. There is a laboratory. PREREQUISITE: PH 2251 or equivalent.

PH 3687 Physics of Electron Interaction in Gases (3-0).
This course stresses the basic electronic processes in gases, fundamental to the physics and chemistry of the upper atmosphere and to the operation of electron devices including the gas laser. Topics covered include elastic collisions, free and ambipolar diffusion, mobility, excitation and ionization, charge transfer emission from surfaces, recombination high frequency, d c, and laser breakdown, sheaths, the glow and arc discharges, radiation, application to the gas laser. PREREQUISITE: PH 3651 or consent of Instructor.

PH 3855 Nuclear Physics (4-2).
This is the first in a sequence of graduate specialization courses on nuclear weapons and their effects. This course deals with the necessary underlying principles of nuclear physics, including nuclear forces, models, stability, reactions and decay processes. The laboratory includes radiation detection techniques and statistics of counting. PREREQUISITES: Courses in Mechanics (PH 3152), Electromagnetism (PH 3360) and Atomic Physics (PH 3651).

PH 3951 Quantum Mechanics (4-0).
The foundation of quantum mechanics and its relation to classical mechanics is studied in depth, enabling the student to obtain a basic understanding of the quantum phenomena investigated in subsequent courses in atomic physics, nuclear physics, electro-optics, etc. Selected applications. PREREQUISITES: PH 2251 and PH 3152.

PH 3952 Electro-Optics (4-0).
This course treats the properties of electro-optic systems together with the basic physical principles involved. Topics included are: diffraction and Fourier transform methods; optical data processing; holography; Fresnel equations, evanescent waves, film and fiber optics; Gaussian beams and laser resonators; molecular spectra, transition probability, line widths, and laser gain; specific lasers, Q-switching and mode locking; semiconductors, Brillouin zones, junction diodes, photodetection, light emitting diodes and diode lasers. PREREQUISITES: PH 3651, a course in electromagnetics, or consent of Instructor.

PH 3998 Special Topics in Intermediate Physics (1-0 to 4-0).
Study in one of the fields of intermediate physics and related applied areas selected to meet special needs or interest of students. The course may be conducted as seminar or supervised reading. It carries a letter grade and may be repeated in different topics. PREREQUISITE: Consent of the Department Chairman. *The course may also be taken on the Pass/Fail basis provided the student has requested so at the time of enrollment.*

Graduate Courses

PH 4171 Advanced Mechanics (4-0).
Hamilton's Principle. The equations of motion in Lagrangian and Hamiltonian form. Symmetries and constants of the motion. The inertia tensor and rigid bodies. Canonical transformation and Poisson brackets. Small oscillations. PREREQUISITES: PH 3152, PH 3360 or equivalent.

PH 4283 Laser Physics (4-0).
The physics of lasers and laser radiation. Topics will include: spontaneous and stimulated emission, absorption, interaction of radiation with matter, line broadening mechanisms, optical and electrical pumping, gain, properties of laser beams, Gaussian beams, stable and unstable resonators, rate equations, output coupling, mode locking, short pulsing, specifics of solid state and gas laser systems, high energy and high power lasers, laser-surface interaction, air breakdown, laser supported detonation waves, laser isotope separation, and laser fusion. PREREQUISITE: PH 3952 or equivalent, or consent of Instructor.

PH 4363 Topics in Advanced Electricity and Magnetism (4-0).
Topics selected from: scattering and absorption of waves by single particles; multiple scattering and radiation transport through random media; relativistic formalism and radiation from accelerated charges; propagation in layered conducting media such as the atmosphere, sea water, ocean floor systems. Introduction to free electron lasers. PREREQUISITES: PH 3352 and MA 3132 or equivalent.

PH 4371 Classical Electrodynamics (3-0).
Tensors in special relativity. Classical relativistic electromagnetic field theory. Lorentz electron theory. PREREQUISITES: PH 4363 and familiarity with the special theory of relativity and Lagrangian mechanics.

PH 4400 Advanced Acoustics Laboratory (0-6).
Advanced laboratory projects in acoustics. PREREQUISITE: PH 3452 or equivalent.

PH 4453 Sound Propagation in the Ocean (4-0).
An advanced treatment of propagation in the ocean. Reflection of spherical wave from ocean boundaries. Normal mode propagation of sound; the inhomogeneous wave equation and the point source in cylindrical coordinates, shallow water channel with penetrable bottom, deep sound channel, WKB approximation. Range-dependent channels; adiabotic normal modes, parabolic equation. Scattering of sound from rough surfaces and in a random ocean; frequency amplitude and phase fluctuations, multipath propagation. PREREQUISITES: PH 3452 or consent of instructor.

PH 4454 Transducer Theory and Design (3-2).
A treatment of the fundamental phenomena basic to the design of transducers for underwater sound, specific examples of their application and design exercises. Topics include piezoelectric, magnetostrictive and hydromechanical effects. Laboratory includes experiments on measurement techniques, properties of transducer materials, characteristics of typical transducer types, and a design project. PREREQUISITE: PH 3452, or consent of Instructor.

PH 4456 Seminar in Application of Underwater Sound (3-0).
A study of current literature on application of acoustics to problems of Naval interest. PREREQUISITE: PH 3431 or 3452 or 4473.

PH 4459 Shock Waves and High-Intensity Sound (3-0).
Nonlinear oscillations and waves on strings. The nonlinear acoustic wave equation and its solution. The parametric array. The physics of shock waves in air and in water. PREREQUISITE: PH 3451.

PH 4473 Advanced Topics in Underwater Acoustics (4-1).
The last in a sequence of course in acoustics for students in the ASW curriculum, this course is a continuation of PH 3472. Topics include: Review of the sonar equations, the eikonal equation and necessary conditions for ray acoustics, normal modes in enclosures, steady-state response of isospeed acoustic waveguides, propagating and evanescent modes, group and phase speeds, the wave equation with a source term, the point source in cylindrical coordinates, transmission loss models for isospeed shallow water channel with fluid bottom, the parabolic equation, and the parametric array. Laboratory experiments include analysis of underwater noise, normal modes in a rectangular cavity, and acoustic waveguides. PREREQUISITE: PH 3472.

PH 4571-4572 Statistical Physics I-II (3-0).
Kinetic theory and the Boltzmann theorem, configuration and phase space, the Liouville theorem, ensemble theory, microcanonical, canonical and grand canonical ensembles, quantum statistics. Application to molecules, Bose-Einstein gases, Fermi-Dirac liquids, and irreversible processes. PREREQUISITES: PH 3152, 3651, Ch 2404 and an upper division course in thermodynamics.

PH 4631 Introduction to Astrophysics (4-0).
Introduction to theories of stellar structure, energy transport in stars, and stellar evolution. Recent advances in astrophysics will be discussed. PREREQUISITE: Consent of Instructor.

PH 4661 Plasma Physics I (4-0).
This course constitutes a broad study of the behavior and properties of gaseous plasma, the fourth — and most abundant — state of matter in the universe. Plasma physics is a vigorously developing branch of contemporary physics. Its many applications are in areas such as astro and space-physics, atomic physics, magneto-hydrodynamic power generation, electron beam excited laser, laser isotope enrichment, ionospheric communication, thermonuclear fusion, and high energy beam weapons. The physical concepts fundamental to various branches of plasma physics are introduced. Topics covered include single particle motions in electromagnetic fields, orbit theory, collision phenomena, breakdown in gases, and diffusion. The magnetohydrodynamic and the two-fluid plasma models are considered. PREREQUISITES: PH 3360, PH 3561, PH 3651, or the equivalent.

PH 4662 Plasma Physics II (3-0).
A continuation of Plasma Physics I. Applications of the hydromagnetic equations to the study of macroscopic motions of plasma. Equilibrium and stability. Classification of plasma instabilities. Kinetic theory, the Boltzmann equation and the macroscopic momentum transport equation. Plasma oscillations and Landau damping. Nonlinear effects, shock waves, radiations from plasma, including bremsstrahlung and cyclotron radiation. Controlled fusion and laser produced plasmas. PREREQUISITES: PH 4363, PH 4661 or equivalent.

PH 4681 Advanced Plasma Physics (3-0).
Selected topics in plasma physics, such as laser-target interaction, dynamics of a laser-produced plasma, self-generated magnetic fields, plasma surface interactions, unipolar arcing, light scattering and absorption in plasma, turbulence and fluctuations, collisionless shock waves. PREREQUISITE: PH 4662 or consent of Instructor.

PH 4750 Radiation Effects in Solids (4-2).
Energy loss of radiation in matter, radiation dosimetry, energy transfer of radiation to matter, theory and spectra of radiation from nuclear weapons, fireball development, electromagnetic pulse phenomena, displacements of atoms in solids, radiation damage to solid-state devices. PREREQUISITES: PH 2810, 3352, and 3651, or equivalents.

PH 4751 Semiconductor Physics (3-1).
Basic physics of semiconductor devices. Band model of solids, carriers (holes and electrons), Fermi function, description of diodes, device fabrication techniques, current and capacitance, various doping distributions, transistors. There is a problem session/lab demonstration. PREREQUISITES: PH 3651 or PH 2241 or Consent of Instructor.

PH 4760 Solid State Physics (4-0).
Fundamental theory and related laboratory experiments dealing with solids: crystals, binding energy, lattice vibration, dislocations and mechanical properties, free electron theory, band theory, properties of semiconductors and insulators, magnetism. PREREQUISITES: PH 3651 and PH 3561 (the latter may be taken concurrently).

PH 4856 Physics of Nuclear Explosions (4-1).
This second course in the nuclear weapon effects graduate specialization sequence considers in depth questions of weapon designs and their specific output environments which are created by the nuclear explosion. Topics are: principles affecting weapon yield efficiency; explosion phenomenology in various ambient environments, blast and shock, thermal radiation, X-rays and gamma rays, neutron fluxes, electromagnetic pulse, radioactive fallout models. PREREQUISITES: PH 3855 and SECRET clearance.

PH 4857 Nuclear Weapon Effects and Hardening Technologies (4-0).
This third course in the nuclear weapon effects graduate specialization sequence considers in detail the effects which nuclear weapon explosion environments have on various defense platforms and systems. Methods of hardening to reduce system vulnerability are considered in each of the effect areas: blast and shock, thermal radiation, transient effects on electronics, EMP, biological effects from contamination, atmospheric and ionospheric effects on communication, detection and surveillance systems. PREREQUISITES: PH 4856, PH 3461 and SECRET clearance.

PH 4881 Advanced Nuclear Physics (3-0).
Topics selected from: relativistic mechanics, scattering of electrons from nuclei, nuclear models, nuclear potentials, relativistic treatent of the electron using the Dirac equation and application to electron scattering to develop the Mott cross-section; treatment of form-factors arising from electron-nucleon and electron-nucleus scattering; application of electron scattering to study the structure of nucleon matter and the study of nucleon models. PREREQUISITE: An upper division course in nuclear physics.

PH 4885 Reactor Theory (3-0).
The diffusion and slowing-down of neutrons. Homogeneous thermal reactors, time behavior; reactor control. Multigroup theory. Heterogeneous systems. PREREQUISITES: An upper division course in nuclear physics.

PH 4952 Sensors, Signals, and Systems (4-2).
This course treats the physical phenomena and practical problems involved in sensor systems for electromagnetic signals. Topics included are: optical modulation, nonlinear optics, acousto-optics; specific lasers, Q-switching and mode locking; atmospheric absorption and scattering of radiation; image intensifiers, television and FLIR systems; detecting, tracking and homing systems; signal sources, target signatures and backgrounds; laser target designators, laser radars, the range equation. The laboratory will include experiments related to this material as well as to that of the preceding course, PH 3952. PREREQUISITES: PH 3952 and a course in electromagnetics.

PH 4953 Physics of the Satellite Environment (4-0).
A graduate level treatment of the structure and properties of the Space environment with emphasis on those aspects which affect military satellites. Topics covered are chosen from: Geomagnetic Field and its variations, Composition and dynamics of the Upper Atmosphere, Natural and artifical radiation belts, Solar emissions and their influence on the near earth space environment. PREREQUISITES: A 3000 level course in electromagnetism and mathematics through partial differential equations.

PH 4954 Particle Beam and High Energy Laser Weapon Physics (4-0).
This course is an indepth study into the beam weapon concepts. Topics covered are: relativistic electron beams; their equilibrium, propagation losses and stability; giant power accelerator concepts; target interaction; proton beams; neutral particle beams, their production and limitations; high power microwave beams, high energy laser beams, their production, atmospheric propagation and control and their interaction with targets. PREREQUISITES: PH 3352, PH 2151 or equivalent, courses in electromagnetism and mechanics. SECRET clearance.

PH 4971 Quantum Mechanics I (4-0).
PH 4972 Quantum Mechanics II (3-0).
PH 4973 Quantum Mechanics III (3-0).
Review of Lagrange's and Hamilton's equations of motion. Poisson brackets. General principles of nonrelativistic quantum mechanics; stationary states. Addition of angular momenta; time-independent and time-dependent perturbation theory; scattering theory; identical particles and spin. General principles of relativistic quantum mechanics; properties and solutions of relativistic wave equations. PREREQUISITES: PH 3651, 3152.

PH 4991 Relativity and Cosmology (3-0).
Einstein's general theory of relativity. The three classical tests. The Schwarzchild singularity and black holes. Cosmological moddels and their relations with observations. Introduction to modern developments; gravitational waves, Dicke's theory, problems of quantum cosmology and superspace. PREREQUISITE: PH 4371.

PH 4998 Special Topics in Advanced Physics (1-0 to 4-0).
Study in one of the fields of advanced physics and related applied areas selected to meet special needs or interests of students. The course may be conducted as a seminar or supervised reading. The course carries a letter grade and may be repeated in different topics. PREREQUISITE: Consent of the Department Chairman. *It may also be taken on a Pass/Fail basis if the student has requested so at the time of enrollment.*

CHEMISTRY

Upper Division Course

CH 2001 General Principles of Chemistry (3-2).
A study of the fundamentals underlying the chemical behavior of matter. Current theories of atomic structure and chemical bonding. Elementary physical chemistry, including chemical equilibria, kinetics and electrochemistry. The laboratory period will be used for physico-chemical experiments or for problem work, as is deemed appropriate by the instructor.

Upper Division or Graduate Courses

CH 3505 Radiation Chemistry (3-0).
A study of the theory behind the chemical processes occurring when ionizing and electromagnetic radiation interact with matter. Includes electronic states of molecules, introduction to photochemistry, properties of gaseous ions and free radicals, chain reactions. PREREQUISITE: Consent of Instructor.

CH 3998 Special Topics in Intermediate Chemistry (1-0 to 4-0).
Study in one of the fields of intermediate chemistry selected to meet special needs or interests of students. The course may be conducted as seminar or supervised reading and carries a letter grade. It may be repeated in different topics. PREREQUISITE: Consent of the Department Chairman. *It may also be taken on Pass/Fail basis if the student has requested so at the time of enrollment.*

Graduate Courses

CH 4410 Chemical Kinetics (3-0).
Experimental methods and interpretations of data. Collison theory and activated-complex theory. Mechanisms of reactions. PREREQUISITE: Consent of Instructor.

CH 4998 Special Topics in Advanced Chemistry (1-0 to 4-0).
Study in one of the fields of advanced chemistry or related applied areas selected to meet special needs or interest of students. The course may be conducted as seminar or supervised reading, carries a letter grade and may be repeated in different topics. PREREQUISITE: Consent of Department Chairman. *It may also be taken on Pass/Fail basis if the student has requested so at the time of enrollment.*

SCIENCE AND ENGINEERING

Upper Division Courses

SE 2002 Electromagnetic Systems (4-0).
This course is designed to support the Intelligence curriculum by providing an overview of the principles, concepts and trade-offs underlying systems whose operations requires the transmission and/or reception of electromagnetic energy. Topics treated in the course include: the electromagnetic spectrum and its usage, principles of electronic reconnaissance, antennas and their characteristics, factors affecting receiver sensitivity, transmission range, radar principles, the radar equation, optics fundamentals, infrared nomenclature, and principles and elements of photographic science.

SE 2279 Directed Studies in Science and Engineering (Credit open).
Independent study in science and engineering topics in which formal course work is not offered. PREREQUISITE: Permission of Department Chairman. *Graded on Pass/Fail basis only. (Graduate students register for SE 3279.)*

Upper Division or Graduate Courses

SE 3004 Weapons System Analysis (4-0).
This course is designed to support the Intelligence curriculum. It treats the process of weapons system synthesis and analysis with special reference to surface to air and surface to surface missiles. Topics covered include: missile engagement analysis, guidance considerations for weapons system design, EDM considerations for defense and penetration, warhead and fusing considerations for weapons system design, and examination of current U.S. and Soviet Systems. PREREQUISITES: SE 2002, EC 2003; SECRET clearance and U.S. citizenship.

SE 3279 Directed Studies in Science and Engineering (Credit open).
(See SE 2279). *Graded on Pass/Fail basis only.*

Graduate Courses

SE 4006 Technical Assessment and Intelligence Systems (4-0).
This course is designed to support the Intelligence curriculum. It treats the role of intelligence in support of the DoD Planning, Programming and Budgeting System, the U.S. and Soviet Military R & D Systems, current technical trends affecting military capabilities, and current and projected capabilities of ocean surveillance and technical intelligence systems. PREREQUISITE: TOP SECRET clearance with access to Special Intelligence Information.

SE 4858 Nuclear Warfare Analysis (4-0).
This final course in the nuclear weapon effects graduate specialization sequence deals with technical aspects of strategic and tactical nuclear war. As much as possible, quantitative considerations will be stressed. PREREQUISITES: PH 4857 or PH 3600 or equivalent; SECRET clearance.

DEFENSE RESOURCES MANAGEMENT EDUCATION CENTER

Discussion groups are an integral part of the educational activity of the Center

Robert H. Shumaker, Rear Admiral, U.S. Navy, Director; B.S., U.S. Naval Academy, 1956; B.S. in Aeronautics, Naval Postgraduate School, 1963; M.S. in Aeroelectronics, 1965; M.S. in Electrical Engineering, 1975; Ph.D. in Electrical Engineering, 1977.

James Sherman Blandin, Associate Professor (1974); Executive Director; B.A., Univ. of California at Santa Barbara, 1968; M.B.A., Univ. of Oregon, 1972; Ph.D., 1974.

Donald E. Bonsper, Lieutenant Colonel, U.S. Marine Corps, Instructor (1982); Program Manager, MET US Defense Courses; B.S., U.S. Naval Academy, 1965; M.S., Naval Postgraduate School, 1970.

Robert Edward Boynton, Associate Professor (1970); B.A., Univ. of Minnesota, 1956; M.A., 1962; Ph.D., Stanford Univ., 1968.

Earl R. Brubaker, Professor (1983); B.S., Pennsylvania State University, 1954; Ph.D., University of Washington, 1964.

Donald H. Conrad, Lieutenant Colonel, U.S.A., Instructor (1985); B.S., U.S. Military Academy, 1963; M.S., Georgia Institute of Technology, 1972.

Philip Atkinson Costain, Adjunct Professor (1979); B.S., U.S. Military Academy, 1962; M.S. in Operations Research, Naval Postgraduate School, 1984.

John Edward Dawson, Professor (1966); B.A., The Principia College, 1953; M.P.A., Syracuse Univ., 1954; D.P.A., 1971.

Edwin John Doran, Adjunct Professor (1975); B.A., Univ. of Pennsylvania, 1955; M.S., Naval Postgraduate School, 1968; M.B.A., Univ. of Santa Clara, 1972; Ph.D., 1977.

Peter Carl Frederiksen, Associate Professor (1974); Assistant Director for Academic Programs, B.A., Golden Gate College, 1967; M.A., San Francisco State College, 1969; Ph.D., Washington State University, 1974.

James P. Ignizio, Visiting Professor (1985); B.S.E.E., Univ. of Akron; M.S.E., Univ. of Alabama (Huntsville); Ph.D., Virginia Polytechnic Institute.

Charles J. LaCivita, Assistant Professor (1985); B.E.E., Univ. of Detroit, 1969; M.B.A., Valdosta State College, 1975; Ph.D., Univ. of California at Santa Barbara, 1981.

James H. Morris, Associate Professor (1982); B.S., San Diego State University, 1971; M.B.A., San Diego State University, 1973; Ph.D., University of Oregon, 1976.

Robert L. Pirog, Assistant Professor (1983); B.A., Muhlenberg College, 1969; M.A., University of Connecticut, 1970; M.Phil., Columbia University, 1975; Ph.D., Columbia University, 1978.

Alexander Wolfgang Rilling, Adjunct Professor (1974); Assistant Director, International Programs Development and Administration; B.S., Rensselaer Polytechnic Institute, 1951; M.S., Naval Postgraduate School, 1962; Ph.D., Univ. of Southern California, 1972.

David Charles Roberts, Assistant Professor (1980); B.A., California State Univ. at Northridge, 1967; M.A., California State Univ. at Los Angeles, 1970; Ph.D., Univ. of Southern California 1976.

Robert von Pagenhardt, Professor (1967); A.B., Stanford Univ., 1948; M.S., 1954; Ph.D., 1970.

Kent D. Wall, Associate Professor (1985); B.M.E., Univ. of Minnesota, 1966; M.S.M.E., 1968; Ph.D., 1971.

Larry E. Vaughn, Lieutenant Commander, SC, USN, Instructor (1985); B.A., Ohio State Univ., 1966; M.A., 1972; M.S., Naval Postgraduate School, 1974.

Frank Yohannan, Major, U.S. Marine Corps, Instructor (1985); B.S., Northern Arizona University; M.B.A., University of Colorado.

Emeritus Faculty

William Ayers Campbell, Professor Emeritus, (1970); B.S., Tuskegee Institute College, 1937; M.S.I.M., Univ. of Pittsburgh Graduate School, 1949.

Frank Elmer Childs, Professor Emeritus (1965); B.A., Willamette Univ., 1934; M.B.A., Univ. of Southern California, 1936; Ph.D., Univ. of Minnesota, 1956.

Ivon William Ulrey, Professor Emeritus (1966); B.S., Ohio State Univ., 1931; M.B.A., New York Univ., 1937; Ph.D., Ohio State Univ., 1953.

Carlton Leroy Wood, Professor Emeritus (1966); B.A., Univ. of Washington, 1932; M.A., Columbia Univ., 1944; Ph.D., Heidelberg Univ., 1936.

**The year of joining the Postgraduate School faculty is indicated in parentheses.*

DEFENSE RESOURCES MANAGEMENT EDUCATION CENTER

Established in 1965 as the Navy Management Systems Center and redesignated to its present title in July 1974, the Defense Resources Management Education Center is a jointly staffed U.S. Department of Defense sponsored educational institution located as a tenant activity at the Naval Postgraduate School. It conducts educational programs in resources management, both in residence at Monterey and on-site, for military officers and civilian defense officials of the U.S. and cooperating foreign nations. The focus of all programs conducted by the Center is on the development of knowledge and improvement of understanding of the concepts, techniques and application of modern defense management, with specific emphasis on analytical decision making. The mission, objectives and responsibilities of the Center are set forth in Department of Defense Directive 5010.35.

The Center currently offers the following resident courses within its facilities at the Naval Postgraduate School:

DEFENSE RESOURCES MANAGEMENT COURSE — four weeks in length; presented five times per year.

INTERNATIONAL DEFENSE MANAGEMENT COURSE — eleven weeks in length; presented twice a year.

SENIOR INTERNATIONAL DEFENSE MANAGEMENT COURSE — four weeks in length; presented once each year (normally in the month of June).

Descriptions of these courses are provided below; detailed information on current quota control agencies and procedures may be found in DOD Publication 5010.16-C (Defense Management Education and Training Catalog).

In addition to its regularly scheduled resident programs, the Center also provides:

MOBILE EDUCATION COURSES — normally two or three weeks in length, for U.S. military services and defense agencies, and for foreign governments upon specific request and approval.

COURSES FOR OTHER AGENCIES — programs of from two to four weeks duration, resident or on-site, for non-defense federal agencies and state and local governments, upon specific request and approval.

Faculty of the Center are members of the faculty of the Naval Postgraduate School on assignment to the Center.

Since 1966, almost 15,000 officials, of whom more than 5,000 represented 78 foreign nations, have participated in programs conducted by the Center.

DEFENSE RESOURCES MANAGEMENT COURSE

The objective of this four-week course is to provide an appreciation of the concepts, principles, and methods of defense management as they concern planning, programming, budgeting, and related activities. Emphasis is placed on the analytical aspects of management, stemming from the disciplines of management decision theory, economics, and quantitative analysis.

Participants are not expected to become experts or technicians in the various disciplines and subjects included in the curriculum. The objectives are to provide orientation on the overall functioning of the defense management process, insights as to what defense management requires in the way of inputs and analysis for decision-making, understanding of the principles, methods and techniques used, and awareness of the interfaces between management requirements of the Defense Department components and the Office of the Secretary of Defense. Course methodology

includes lectures, small group discussions reinforced by illustrated case studies and problem sets, as well as selected daily reading assignments.

This course is primarily for U.S. officials, although limited numbers of foreign participants are normally also enrolled.

INTERNATIONAL DEFENSE MANAGEMENT COURSE

The course is designed for participants in the military grades of 0-4 (Major/Lieutenant Commander) through 0-6 (Colonel/Captain) and defense related civilians of equivalent rank. Enrollment is currently limited to a maximum of 50 participants. Broad national representation is desired for this course, i.e., participation of at least eight or ten nations enhances the value of the comparative management aspects of the curriculum.

The course is presented in English.

The course provides a series of lectures in three major areas: environmental factors; quantitative and economic analysis; and management systems in the context of strategy, implementation, and operations. The lectures are supplemented by small group discussions and workshops which concentrate on the lecture topics and associated readings, problems and cases. In the discussion groups, faculty members guide the interchange of ideas and are available to answer questions. Readings are assigned from within texts and supplemental material given to the participants to facilitate preparation for each lecture. Lecture outlines with additional suggested reading lists are provided. Occasional open seminar speakers are invited for special topics.

Early in the course, participants are requested to give brief presentations (by country) on their particular environmental situations, including such information as geographic factors, economic factors, social and cultural considerations, governmental and defense organizations, and unique management situations and/or problems. Throughout the course, the participants are encouraged to present and discuss information with respect to the defense management systems of their countries, and to examine how the management concepts and techniques discussed by both the Center faculty and the participants from other countries may be applied in their own situations. Comparative study by means of interaction among participants is considered to be an extremely valuable characteristic of the course.

During the course, the Center conducts field trips to selected military and commercial installations in the central California area. These trips provide an opportunity for the participants to receive special briefings on management techniques and problems, and to observe actual practices at the operating level.

In the second half of the course the general concepts of defense management are elaborated in detail during the examination of actual systems in financial, material and human recources management. At the end of the course a general review integrates the formal course material, special topics, and field trip experiences.

SENIOR INTERNATIONAL DEFENSE MANAGEMENT COURSE

Enrollment is restricted to military flag and general officers (grades 0-7 and above) and defense-related civilians of equivalent rank, except that for countries where the 0-6 grade is comparable to flag/general rank such officials may be enrolled on a waiver basis. Participation in this course is normally from 40 to 50 senior officials from as many as 22 countries.

The course is presented in English.

The lecture, small discussion group, environmental seminar, case study and problem format and content described above for IDMC also applies, but compressed in time. Two or three guest speakers, including at least one high level official in a policy position in a foreign government, are invited to address the class and a short field trip is conducted.

TENTATIVE FY 86 SCHEDULE OF RESIDENT COURSES

IDMC 85-2 (11 weeks)	16 Sep - 27 Nov 85
DRMC 86-1 (4 weeks)	6 Jan - 31 Jan 86
IDMC 86-1 (11 weeks)	3 Feb - 16 Apr 86
DRMC 86-2 (4 weeks)	21 Apr - 15 May 86
DRMC 86-3 (4 weeks)	19 May - 13 Jun 86
SIDMC 86 (4 weeks)	23 Jun - 18 Jul 86
DRMC 86-4 (4 weeks)	21 Jul - 14 Aug 86
DRMC 86-5 (4 weeks)	18 Aug - 12 Sep 86
IDMC 86-2 (11 weeks)	15 Sep - 26 Nov 86

NOTE: The above dates are tentative and subject to change.

DISTINGUISHED ALUMNI

Among those U.S. officers who have completed a curricular program at the Naval Postgraduate School, the following officers (USN or USMC unless otherwise indicated) have attained flag rank on the active list:

Admiral Walter F. Boone
Admiral Arleigh A. Burke
Admiral Cato D. Glover, Jr.
Admiral Charles D. Griffin
Admiral Ephraim P. Holmes
Admiral George E.R. Kinnear, II
Admiral Frederick H. Michaelis
Admiral Alfred M. Pride
Admiral James S. Russell
Admiral Ulysses S. G. Sharp, Jr.
Admiral Harry D. Train, II
Admiral James D. Watkins*
Vice Admiral Robert E. Adamson, Jr.
Vice Admiral Frederick L. Ashworth
Lieutenant General George C. Axtell, Jr.
Vice Admiral Lee Baggett, Jr.*
Vice Admiral George F. Beardsley
Vice Admiral Fred G. Bennett
Vice Admiral Charles T. Booth, II
Vice Admiral Harold G. Bowen, Jr.
Vice Admiral Jon L. Boyes
Vice Admiral Edward S. Briggs*
Vice Admiral Carleton F. Bryant
Vice Admiral James B. Busey*
Vice Admiral Wayne E. Caldwell, USCG*
Vice Admiral William M. Callaghan
Vice Admiral Kent J. Carroll*
Vice Admiral Ralph W. Christie
Vice Admiral John B. Colwell
Vice Admiral Thomas F. Connolly
Vice Admiral Vincent P. Depoix
Vice Admiral Harold T. Deutermann
Vice Admiral Glynn R. Donaho
Vice Admiral Robert F. Dunn*
Vice Admiral Crawford A. Easterling*
Vice Admiral Clarence E. Ekstrom
Vice Admiral Albert J. Fay
Vice Admiral William E. Gentner, Jr.
Vice Admiral Arthur R. Gralla
Vice Admiral Truman J. Hedding
Vice Admiral "M" Staser Holcomb*
Vice Admiral Edwin B. Hooper
Vice Admiral Thomas J. Hughes, Jr.*
Vice Admiral Thomas B. Inglis
Vice Admiral Andrew M. Jackson, Jr.
Vice Admiral Donald S. Jones*
Vice Admiral Robert T.S. Keith
Vice Admiral Ingolf N. Kiland
Vice Admiral Thomas J. Kilcline*
Vice Admiral Jerome H. King, Jr.
Vice Admiral Robert E. Kirksey*
Vice Admiral Harold O. Larson
Vice Admiral Kent L. Lee
Vice Admiral Ruthven E. Libby
Vice Admiral Vernon L. Lowrance
Lieutenant General William R. Maloney
Vice Admiral Kleber S. Masterson
Vice Admiral Ralph E. McShane
Vice Admiral Joseph Metcalf, III*
Lieutenant General John H. Miller
Vice Admiral Richard A. Miller*
Vice Admiral Henry C. Mustin*
Vice Admiral Lloyd M. Mustin
Vice Admiral Gordon R. Nagler*
Vice Admiral Frank O'Beirne
Vice Admiral Howard E. Orem
Vice Admiral Edward N. Parker
Vice Admiral Raymond E. Peet
Vice Admiral Forrest S. Petersen
Vice Admiral Thomas C. Ragan
Vice Admiral Lawson P. Ramage
Vice Admiral William L. Rees
Vice Admiral Robert H. Rice
Vice Admiral Rufus E. Rose
Vice Admiral William H. Rowden*
Vice Admiral Theodore D. Ruddock, Jr.
Vice Admiral Lorenzo S. Sabin
Vice Admiral Harry Sanders
Vice Admiral James R. Sanderson*
Vice Admiral Walter G. Schindler
Vice Admiral Harry C. Schrader, Jr.*
Vice Admiral Harry E. Sears
Vice Admiral Ernest R. Seymour*
Vice Admiral Wallace B. Short
Lieutenant General Philip D. Shutler
Vice Admiral William R. Smedberg, III
Vice Admiral John V. Smith
Vice Admiral Roland N. Smoot
Vice Admiral Thomas M. Stokes
Vice Admiral John Sylvester
Vice Admiral George C. Towner
Vice Admiral Robert L. Townsend

Vice Admiral Thomas J. Walker, III
Vice Admiral Edward C. Waller, III*
Vice Admiral Robert L. Walters*
Vice Admiral Charles Wellborn, Jr.
Vice Admiral Thomas R. Weschler
Vice Admiral Ralph Weymouth
Vice Admiral Ralph E. Wilson
Rear Admiral William C. Abhau
Rear Admiral Charles Adair
Rear Admiral Frank Akers
Rear Admiral Theodore A. Almstedt, Jr.*
Rear Admiral David M. Altwegg*
Rear Admiral Charles C. Anderson
Rear Admiral Herbert H. Anderson
Rear Admiral Roy G. Anderson
Rear Admiral William L. Anderson
Rear Admiral Burton H. Andrews
Rear Admiral Henry J. Armstrong
Rear Admiral Henry D. Arnold
Rear Admiral Stanley R. Arthur*
Rear Admiral James W. Austin*
Rear Admiral Robert C. Austin*
Rear Admiral Warren E. Aut*
Rear Admiral Richard C. Avrit*
Rear Admiral William B. Bailey
Rear Admiral Fred E. Bakutis
Rear Admiral Nathaniel C. Barker
Rear Admiral Edwin Barrineau
Rear Admiral Joseph J. Barth, Jr.*
Rear Admiral John R. Batzler*
Rear Admiral Robert L. Baughan, Jr.
Rear Admiral Fred H. Baughman
Rear Admiral John D. Beecher*
Rear Admiral John K. Beling
Rear Admiral David B. Bell
Rear Admiral Allen A. Bergner
Rear Admiral Philip A. Beshany
Rear Admiral Ralph G. Bird*
Rear Admiral Worthington S. Bitler
Rear Admiral Wayne D. Bodensteiner*
Rear Admiral Calvin M. Bolster
Rear Admiral Selman S. Bowling
Rear Admiral Harold M. Briggs
Rear Admiral Clarence Broussard
Rear Admiral Henry C. Bruton
Rear Admiral Charles A. Buchanan
Rear Admiral Raymond W. Burk
Rear Admiral John L. Butts*
Rear Admiral William M. Callaghan, Jr.
Rear Admiral Joseph W. Callahan
Rear Admiral Lucien Capone, Jr.
Rear Admiral Harold A. Carlisle
Rear Admiral Edward W. Carter, III*
Rear Admiral Gordon L. Caswell
Rear Admiral Robert W. Cavenagh
Rear Admiral Lawrence C. Chambers*
Rear Admiral Lester S. Chambers
Rear Admiral Ming E. Chang*
Rear Admiral John D. Chase
Rear Admiral Kenan C. Childers, Jr.
Rear Admiral William P. Chilton
Rear Admiral Ernest E. Christensen
Rear Admiral Thomas J. Christman
Rear Admiral Karl J. Christoph, Jr.
Rear Admiral Albert H. Clancy, Jr.
Rear Admiral David H. Clark
Rear Admiral Glenwood Clark, Jr.*
Rear Admiral Henry G. Clark
Rear Admiral Jeane R. Clark
Rear Admiral Neal W. Clements
Rear Admiral Leonidas D. Coates, Jr.
Rear Admiral James E. Cohn
Rear Admiral Philip P. Cole
Rear Admiral William M. Cole
Major General Clayton L. Comfort*
Rear Admiral Byran W. Compton, Jr.*
Rear Admiral Warren M. Cone
Rear Admiral Donald L. Conner*
Rear Admiral Robert C. Conolly, II
Rear Admiral Peter C. Conrad*
Rear Admiral Murray C. Cook
Rear Admiral Samuel M. Cooley, Jr.
Rear Admiral Joshua W. Cooper
Rear Admiral Frank W. Corley, Jr.
Rear Admiral John T. Corwin
Rear Admiral John D. Costello, USCG*
Rear Admiral John T. Coughlin
Rear Admiral Stanley T. Counts
Rear Admiral John E. Dacey
Rear Admiral James A. Dare
Rear Admiral Cabell S. Davis, Jr.
Rear Admiral George W. Davis, Jr.*
Rear Admiral Henry J. Davis, Jr.
Rear Admiral James W. Davis
Rear Admiral John B. Davis, Jr.
Rear Admiral Ranson K. Davis
Rear Admiral Tyler F. Dedman
Rear Admiral Paul W. Dillingham, Jr.*
Rear Admiral Ernest W. Dobie, Jr.
Rear Admiral Frank R. Dodge
Rear Admiral Joseph E. Dodson
Rear Admiral Oscar H. Dodson
Rear Admiral Marshall E. Dorin
Rear Admiral Wallace R. Dowd, Jr.
Rear Admiral Clayton R. Dudley
Rear Admiral Clifford H. Duerfeldt
Rear Admiral Scott W. Ebert*
Rear Admiral Henry E. Eccles
Rear Admiral Edward H. Eckelmeyer, Jr.

Rear Admiral Claude P. Ekas, Jr.
Rear Admiral Donald T. Eller
Rear Admiral Robert B. Ellis
Rear Admiral Paul H. Engel
Major General William R. Etnyre
Rear Admiral Gordon S. Everett
Rear Admiral Delmer S. Fahrney
Rear Admiral Edward J. Fahy
Rear Admiral James M. Farrin, Jr.
Rear Admiral Emerson E. Fawkes
Rear Admiral Donald L. Felt*
Rear Admiral James M. Fernald
Rear Admiral William E. Ferrall
Rear Admiral Lee W. Fisher
Rear Admiral Francis J. Fitzpatrick
Rear Admiral Morton K. Fleming, Jr.
Rear Admiral William O. Floyd
Rear Admiral Thomas E. Flynn
Rear Admiral Robert J. Foley
Rear Admiral Richard K. Fontaine
Rear Admiral Edward C. Forsyth
Rear Admiral James H. Foxgrover
Rear Admiral John E. Fradd
Rear Admiral George K. Fraser
Rear Admiral Joseph F. Frick*
Rear Admiral George M. Furlong, Jr.*
Rear Admiral Frederick R. Furth
Rear Admiral Walter D. Gaddis
Rear Admiral Ralph M. Ghormley*
Rear Admiral Paul C. Gibbons, Jr.
Rear Admiral Donald T. Giles
Rear Admiral Fillmore B. Gilkeson
Rear Admiral John A Glick
Rear Admiral Alexander S. Goodfellow, Jr.
Rear Admiral Etheridge Grant
Rear Admiral Alfred M. Granum
Rear Admiral Norman K. Green
Rear Admiral Richard J. Grich*
Rear Admiral Bradford E. Grow
Rear Admiral William A. Gureck*
Rear Admiral Frank S. Haak
Rear Admiral Benjamin T. Hacker*
Rear Admiral Hamilton Hains
Rear Admiral Grover B.H. Hall
Rear Admiral Warren C. Hamm, Jr.*
Rear Admiral David L. Harlow*
Rear Admiral Harold S. Harnly
Rear Admiral William L. Harris, Jr.
Rear Admiral Clarence M. Hart
Rear Admiral Pauline M. Hartington*
Rear Admiral Robert S. Hatcher
Rear Admiral Valery Havard, Jr.
Rear Admiral Hugh E. Haven
Rear Admiral Kenneth G. Haynes
Rear Admiral Vincent P. Healey
Rear Admiral George L. Heath
Rear Admiral Ralph R. Hedges*
Rear Admiral Peter M. Hekman, Jr.*
Rear Admiral Guy B. Helmick
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Rear Admiral Lee R. Herring
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Rear Admiral Bobby F. Hollingsworth, USCG*
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Rear Admiral Miles H. Hubbard
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Rear Admiral Harry R. Hummer, Jr.
Rear Admiral George P. Hunter
Rear Admiral William D. Irvin
Rear Admiral Joseph A. Jaap
Major General Samuel S. Jack
Rear Admiral David H. Jackson
Rear Admiral Dempster M. Jackson*
Rear Admiral Jack M. James
Rear Admiral Ralph K. James
Rear Admiral Joseph F. Jelley, Jr.
Rear Admiral George E. Jessen
Rear Admiral Roger D. Johnson*
Rear Admiral Fred W. Johnston, Jr.*
Rear Admiral Harry D. Johnston
Rear Admiral Horace B. Jones
Rear Admiral Allen R. Joyce
Rear Admiral Benjamin Katz
Rear Admiral William A. Kearns, Jr.*
Rear Admiral Bruce Keener, III
Rear Admiral Thomas J. Kelly
Rear Admiral John D. Kelsey
Rear Admiral Cecil J. Kempf*
Rear Admiral Marvin G. Kennedy
Rear Admiral John S. Kern
Rear Admiral William M. Klee
Rear Admiral Verle W. Klein*
Rear Admiral Arthur K. Knoizen*
Rear Admiral Denys W. Knoll
Rear Admiral Theodore H. Kobey
Rear Admiral Leland S. Kollmorgen
Rear Admiral Edgar P. Kranzfelder
Rear Admiral William E. Kuntz

Rear Admiral David Lambert
Major General Frank H. Lamson-Scribner
Rear Admiral Richard A. Larkin
Rear Admiral Robert E. Laub
Rear Admiral Paul A. Lautermilch, Jr.*
Rear Admiral Martin J. Lawrence
Brigadier General George H. Leach*
Rear Admiral William H. Leahy
Rear Admiral William E. Lemos
Rear Admiral Glen W. Lenox
Rear Admiral Lee E. Levenson*
Rear Admiral Isham W. Linder
Rear Admiral William H. Livingston
Rear Admiral Walter M. Locke*
Rear Admiral Theodore C. Lonnquest
Rear Admiral Wayne R. Loud
Major General Anthony Lukeman
Rear Admiral Duncan C. MacMillan
Rear Admiral Charles J. Maguire
Rear Admiral Joseph B. Maher
Rear Admiral Robert C. Mandeville, Jr.
Rear Admiral Francis F. Manganaro
Rear Admiral Harry C. Mason
Rear Admiral Kleber S. Masterson, Jr.
Rear Admiral Bob O. Mathews
Rear Admiral William S. Maxwell
Rear Admiral John C. McArthur*
Rear Admiral James E. McCardell, Jr.*
Rear Admiral Paul F. McCarthy, Jr.*
Rear Admiral Brian McCauley
Rear Admiral Thomas R. McClellan
Rear Admiral Melvyn H. McCoy
Rear Admiral Francis C.B. McCune
Rear Admiral William E. McGarrah, Jr.*
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Rear Admiral Logan McKee
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Rear Admiral Philip S. McManus
Rear Admiral Robert W. McNitt
Rear Admiral Robert E. Melling
Rear Admiral Wm. K. Mendenhall, Jr.
Rear Admiral Wayne E. Meyer*
Rear Admiral George H. Miller
Rear Admiral Rupert S. Miller
Rear Admiral Robert G. Mills
Rear Admiral Charles J. Moore*
Rear Admiral Robert L. Moore, Jr.
Rear Admiral Virgil W. Moore, Jr.*
Rear Admiral Kendall E. Moranville*
Rear Admiral Henry G. Moran
Rear Admiral Armand M. Morgan
Rear Admiral James B. Morin
Rear Admiral Robert W. Morse
Rear Admiral Douglas F. Mow
Rear Admiral Paul J. Mulloy*
Rear Admiral John W. Murphy, Jr.
Rear Admiral James D. Murray, Jr.
Rear Admiral Ronald E. Narmi*
Rear Admiral Frederick J. Nelson
Major General Noah C. New
Rear Admiral Byron B. Newell, Jr.*
Rear Admiral Charles A. Nicholson, II
Rear Admiral William R.D. Nickelson, Jr.
Rear Admiral Hugh R. Nieman, Jr.
Rear Admiral William Nivison
Rear Admiral John W. Nyquist*
Rear Admiral Emmet O'Beirne
Rear Admiral Timothy J. O'Brien
Rear Admiral Edward J. O'Donnell
Rear Admiral Jack F. O'Hara
Rear Admiral William H. Organ
Rear Admiral James B. Osborn
Rear Admiral William W. Outerbridge
Rear Admiral Thomas B. Owen
Rear Admiral Samuel H. Packer, II*
Rear Admiral Roger W. Paine, Jr.
Rear Admiral Frederick F. Palmer
Rear Admiral Charles W. Parker
Rear Admiral Goldsborough S. Patrick
Rear Admiral John H. Pedersen
Rear Admiral Henry S. Persons
Rear Admiral Richard H. Phillips
Rear Admiral Ben B. Pickett
Rear Admiral Paul E. Pihl
Rear Admiral Frank L. Pinney, Jr.
Rear Admiral Walter T. Piotti, Jr.*
Rear Admiral Donald T. Poe
Rear Admiral Karl F. Poehlmann
Rear Admiral Bruno A. Pomponio*
Rear Admiral Frank H. Price, Jr.
Rear Admiral Walter H. Price
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Rear Admiral William M. Pugh, II
Rear Admiral Schuyler N. Pyne
Rear Admiral William T. Rassieur
Rear Admiral Charles F. Rauch, Jr.
Rear Admiral Ralph W. Rawson
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Rear Admiral Thomas H. Replogle
Rear Admiral Joseph E. Rice
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Rear Admiral Donald P. Roane*
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Rear Admiral Theodore A. Torgerson
Rear Admiral Jerry O. Tuttle*
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Rear Admiral Frank Virden
Rear Admiral John R. Wadleigh
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Rear Admiral William A. Walsh*
Rear Admiral Thomas M. Ward, Jr.*
Rear Admiral Frederick B. Warder
Rear Admiral Robert W. Watkins
Rear Admiral Odale D. Waters, Jr.
Rear Admiral Thomas C. Watson, Jr.*
Rear Admiral David A. Webster
Rear Admiral John F. Wegforth
Rear Admiral Daniel K. Weitzenfeld
Rear Admiral Albert A. Wellings
Major General Joseph J. Went
Rear Admiral Robert H. Wertheim
Rear Admiral Walter J. Whipple
Rear Admiral David C. White
Rear Admiral William J. Whiteside
Rear Admiral Edwin R. Wilkinson
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Rear Admiral Louis A. Williams*
Rear Admiral Delbert F. Williamson
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Commodore Roger Bigelow Horne, Jr.*
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Commodore John Henry Kirkpatrick*
Brigadier General George H. Leach*
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Brigadier General Jarvis D. Lynch*
Commodore Kenneth C. Malley*
Commodore Henry H. Mauz, Jr.
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Brigadier General Robert F. Milligan*
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Commodore Harry Stillman Quast*
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Commodore William D. Zirbel*

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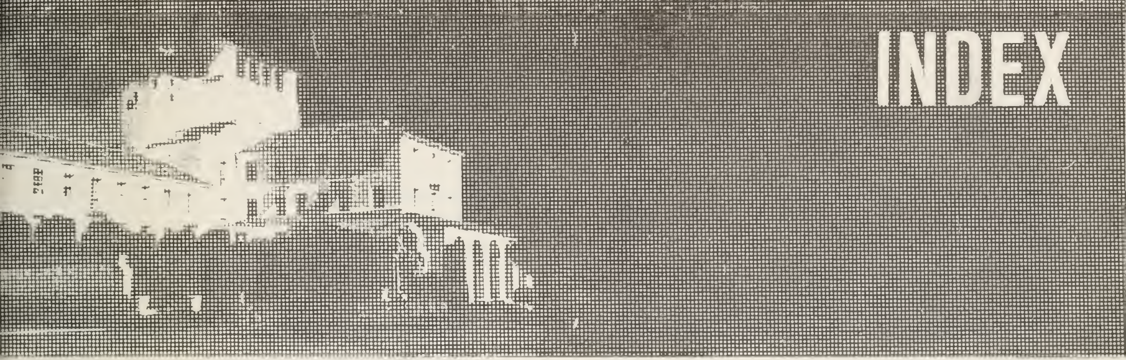
Commodore Roland G. Guilbault*
Commodore Thomas T. Matterson, USCG*
Commodore Eric A. Mcvadon*
Commodore William F. Merlin, USCG*
Commodore James E. Miller*
Commodore Richard D. Milligan*
Commodore Daniel C. Richardson*
Commodore David N. Rogers*
Commodore James E. Taylor*
Commodore Robert L. Topping*

** The asterisk indicates those on active list as of 1 January 1985*

POSTGRADUATE SCHOOL STATISTICS
GRADUATES BY CALENDAR YEARS

	1946-1955	1956-1965	1966-1975	1976-1982	1983	1984	TOTAL
Bachelor of Arts	....	180	738	1	....	....	919
B.S. in Aeronautical Engineering	285	393	76	....	2	....	756
B.S. in Chemistry	....	6	13	....	....	....	19
B.S. in Engineering Acoustics	....	....	3	5	....	....	8
B.S. in Electrical Engineering	448	752	494	140	8	4	1,846
B.S. in Engineering Science	....	....	276	1	....	....	277
B.S. in Environmental Science	....	12	....	....	....	....	12
B.S. in Management	....	53	1	....	1	....	55
B.S. in Mechanical Engineering	159	134	79	29	1	....	402
B.S. in Meteorology	120	185	78	....	....	....	383
B.S. in Operations Research	....	....	112	26	2	1	141
B.S. in Physics	15	111	54	5	....	1	186
B.S. in Systems Technology	....	....	....	8	....	1	9
Bachelor of Science	56	677	469	23	....	....	1,225
Total Baccalaureate Degrees	1,083	2,503	2,393	238	14	7	6,238
M.A. in National Security Affairs	....	....	23	397	89	95	604
M.S. in Aeronautical Engineering	....	40	339	196	40	45	660
M.S. in Applied Mathematics	....	....	....	10	1	....	11
M.S. in Applied Science	....	....	....	43	....	1	44
M.S. in Chemistry	....	21	48	....	....	....	69
M.S. in Computer Science	....	....	173	216	40	48	477
M.S. in Computer Systems Management	....	22	541	210	....	....	773
M.S. in Electrical Engineering	229	314	663	449	67	62	1,784
M.S. in Engineering Acoustics	....	....	50	46	4	11	111
M.S. in Engineering Science	....	....	....	66	14	23	103
M.S. in Hydrographic Sciences	....	....	....	....	5	6	11
M.S. in Information Systems	....	....	....	93	34	58	185
M.S. in Management	....	406	1597	926	160	165	3,254
M.S. in Material Science	....	5	9	....	....	....	14
M.S. in Mechanical Engineering	56	97	231	208	45	44	681
M.S. in Meteorology	42	93	179	44	2	6	366
M.S. in Oceanography	....	....	298	94	3	2	397
M.S. in Meteorology and Oceanography	....	....	....	72	18	29	119
M.S. in Operations Research	....	63	854	397	64	62	1,440
M.S. in Physics	25	239	226	110	16	16	632
M.S. in Systems Engineering	....	....	....	....	....	14	14
M.S. in Systems Technology	....	....	19	300	64	59	442
M.S. in Telecommunications Systems Management	....	....	....	54	18	18	90
Master of Science	17	167	81	5	....	....	270
Total Master's Degrees	369	1,467	5,331	3,936	684	764	12,551
Aeronautical Engineer	....	4	78	24	5	2	113
Electrical Engineer	....	....	104	53	5	4	166
Mechanical Engineer	....	....	31	40	4	7	82
Total Engineer's Degrees	....	4	213	117	14	13	361
Doctor of Philosophy	....	15	63	33	4	1	116
Doctor of Engineering	....	....	....	3	....	2	6
Total Doctorates	....	15	63	36	4	3	121
Total Degrees	1,452	3,989	8,000	4,327	716	787	19,271



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NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA